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DEVELOPMENT AND TESTING OF SUSTAINABLE AGROFORESTRY MODELS IN DIFFERENT AGROCLIMATIC ZONES OF KERALA WITH EMPHASIS ON SOCIO-CULTURAL, ECONOMIC, TECHNICAL AND INSTITUTIONAL FACTORS AFFECTING THE SECTOR

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Development and Testing of Sustainable Agroforestry Models in different Agroclimatic zones of Kerala with emphasis on Socio-Cultural, Economic, Technical and Institutional factors affecting the Sector

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ABSTRACT OF PROJECT PROPOSAL

Project No.	:	KFRI 346/2000
Title of the project	:	Development and testing of sustainable agroforestry models in different agroclimatic zones of Kerala with emphasis on socio-cultural, economic, technical and institutional factors affecting the sector.
Objectives	:	To design and establish appropriate agroforestry models for different agroclimatic zones of Kerala, emphasising on the prevailing ecological, socio-economic, cultural and institutional factors.
Expected outcome	:	Development of more imaginative agroforestry models by involving farmers, which appropriately fit to the rural landscapes of the state.
Date of commencement	:	April 2000
Scheduled date of completion	:	March 2002
Funded by	:	Kerala Forestry Project (World Bank) Kerala Forest Department
Principal Investigator	:	Dr. S Sankar
Co-Investigator	:	Dr. UM Chandrasekhara

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ABSTRACT

The present project was taken up to develop some understanding that can guide the design of policies for converting the homegarden into economically viable enterprises while still retaining features of biodiversity, ecological benefits, sociocultural acceptance, etc. Survey of homegardens was conducted in seven agroclimatic zones of the State. Homegardens were classified into small, medium and large according to size of the land holding. General features of the homegarden, horizontal and vertical community structure, indices of diversity, contributions of homegardens to income of family were determined. In four agroclimatic zones intervention to enhance the productivity was attempted by introduction of annual crops, multipurpose tree species, medicinal plants, fruit crops and plantation/cash crops after holding elaborate discussions with farmers and stakeholders.

In general, homegardens in all zones had high diversity with a greater index of diversity in large homegardens. Large and medium homegardens contributed more to the family income than small homegardens. There was a tendency to practise monoculture in medium and large homegardens. Analysis of the vertical strata of homegardens provided information on space available for introducing multipurpose tree species in homegardens. Space was more available in medium and large homegardens. The small homegardens are already over saturated in the horizontal and vertical strata. Within the existing framework of homesteads, with variations in the species choice and incorporation of multipurpose tree species, five homestead models are proposed. The models are coconut based, arecanut based, coffee based, mixed and tree based.

Government policies, markets, market signals and information play a major role in strengthening the homegarden resource base. It is high time to promote introduction of Multi-Purpose Tree (MPT) species in homegardens, which requires creation of institution and mechanisms, supply of good quality planting materials: also a package of practices for tree growing and management in homegardens should be developed. Realistic value assessment of wood and other products should be ensured and value addition and market facilities be provided. The Kerala Forest Department has been identified as the agency to promote cultivation of trees outside forests especially homegardens.

1. INTRODUCTION

Tropical homegardens, especially those in Kerala, have provided sustenance to thousands of farmers, ecological stability in the region and at times high economic returns. Kerala consists of nearly 3-4 million homegardens (HGs), where 30 million people reside, earn a living and enjoy the direct and indirect benefits of the system. Indeed, one of the weaknesses of Kerala homegardens is that these are small in size (<1Ha) .The holding size is getting reduced from generation to generation. Further, there have been noticeable changes in the species composition and structure. There is a tendency to shift from polycrops to monocrops. The multistoried and multi-species homegardens face a competitor - a competitor in the economic sense from monoculture plantations of rubber, arecanut and coconut. Hence, during the past few decades a shift has taken place at ever-growing speed from homegardens to other systems of land management. Government policies, market failures and lack of information on tree crops have contributed to this change. Further, the homegarden concept is changing from subsistence to an economically viable enterprise. Hence, there have been ill-conceived notions, policies and hence failures.

Hence, revival of the homegarden system, but in new dimension, is the need of the day. An analysis of the existing system, its contribution to economy, the species diversity and use, and more importantly the availability of horizontal and vertical space for new introduction, is warranted. This project attempts to look into these aspects with the following objective:

To design and establish appropriate agroforestry models for different agroclimatic zones of Kerala, emphasizing on the prevailing ecological, socio-economic, cultural and institutional factors

2. STUDY AREA AND METHODS

2.1 Study area

The State of Kerala has humid tropical climate with an annual rainfall exceeding 2000 mm and mean annual temperature about 27^0C. The percapita cultivable area is only 0.09 ha (Kerala State Land Use Board, 1989). The average size of an operational holding is 0.43 ha (Govt. of Kerala, 1988) with very high cropping intensity (133%). On the basis of topography, soils and sea water intrusion, the state of Kerala is classified into eight agroclimatic zones on which the present study was carried out to develop new agroforestry models which are socially, culturally and economically well accepted by all in the respective zones. Each agroclimatic zone has characteristic locality conditions, natural vegetation and different socio-economic and cultural set up. During the study, we covered seven zones namely: Southern, Central, Northern, High -range, Onattukara, Kole and Dry (Low rainfall) zone (Fig.2.1).

2.2. Methods

2.2.1. Sampling

The fieldwork involved detailed household surveys of homegardens (HGs) belonging to small (< 0.4 ha), medium (0.41-1.2 ha) and large (>1.2 ha) homegardens. These homegardens were identified through a stratified random sampling technique. Three homegardens were randomly selected for detailed phyto-sociological survey from each category of homegardens.

2.2.2. General features of HGs

Information on social and economic features of the HGs was collected through discussion with farmers, agricultural officers and officials of the departments concerned.

2.2.3 Classes of Homegardens (HGs)

On the basis of the presence of components, the HGs were classified into four categories:

1. Pure homestead (homegarden)
2. Homegarden with monoculture
3. Homegarden with livestock (milch animal) and
4. Homegarden with others (pisiculture/ apiculture/sericulture etc.)

2.2.4 Income share of homegarden and women's role in homegarden management

Based on income derived from the homestead farming, homesteads were grouped in to three classes viz.,

Class 1. Household income less than 25% from HGs

Class2. Household income between 25-50 % from HGs and

Class 3.Household income more than 50 % from HGs.

2.2.5. Vegetation survey

2.2.5.1. Horizontal community structure of HGs

The quantitative assessment to understand horizontal community structure was carried out in each category of HGs using 10x10 m quadrats. The size and number of quadrats depended on size, degree of heterogeneity of vegetation and shape of homegardens. However complete survey was made in the homegardens where vegetation was highly heterogeneous and/or HG was small in size. Besides, a series of quadrats were laid from nucleus to boundary to understand species diversity change in the homegardens. The total height, crown radius and girth at breast height (1.37 m) of trees of all individuals in the HGs were recorded. Weeds, seasonal crops and grasses were not included in the present study.

The plants, functionally grouped into timber, fruit, spices, plantation crops, annual crops and medicinal plants were recorded by quadratwise and homesteadwise. The vegetation was quantitatively analysed for frequency, density and dominance as suggested by Phillips (1959).

2.2.5.1.2. Ecological indices of the community of homestead

a). Shannon-Wiener diversity index (H')

The species diversity was calculated by using Shannon-Wiener diversity index (H)

$$H' = - \sum_{i=1}^{S} Pi \log Pi$$

Where $Pi = ni/N$

ni = Number of individuals of a species

N = Total number of value of all species (Shannon-Wiener,1963).

b). Simpson's diversity index (D)

The Simpson's diversity index (D) was calculated by using Simpson's index (Simpson, 1949)

$$Ds = 1- \sum_{i=1}^{s} (ni /N)^2$$

Where ni and N were same as for Shannon- Wiener diversity index.

2.2.6. Vertical structure of homegardens

Based on the height of the plants, the vertical structure of the homegardens was analysed by stratifying the individuals into five strata viz., S0 (plants < 2 m high); S1, (plants 2-7 m); S2, (plants 7-12 m); S3 (plants 12-16 m); S4 (plants > 16 m) in each category of homesteads in seven agroclimatic zones of Kerala.

2.2.7. Interventions for developing new agroforestry models

Formal interviews and group discussions were held with concerned farmers to list out possible interventions to enhance productivity of the homegardens and to develop new agroforestry models. According to the farmers' request, interventions were made in four agroclimatic zones namely: Kole, Central, Dry and High Range zone, after completing basic surveys. The targeted interventions could not be done in the other four agroclimatic zones due to lack of time. However, basic surveys have been made in them.

3. RESULTS AND DISCUSSION

3.1. Southern zone

3.1.1. General features

Southern agroclimatic zone includes districts of Thiruvanthapuram, Kollam, Pathanamthitta and Kottayam. It lies between North latitudes $8^{o}17'$ and $10^{o}21'$ and between East longitudes $76^{o}17'$ and $77^{o}25'$. Altitude range was 7.5 m-750 m. The total geographical area of this zone is 673875 ha. The zone receives rainfall from both South- West and North-East monsoons. Mean annual rainfall is 1750-3000 mm, 1880-3500 and 2000-3500 mm in the lowland, midland and highland respectively. The mean annual temperature ranges between 22.5 and 32.8 ^{o} C and minimum temperature is 23 ^{o}C-23-4 ^{o}C. The mean relative humidity varies from 76.8 per cent at Punalur to 80 per cent at Alappuzha. The predominant soil groups are K09, K91, K32 and K36. K09-Ramanthatti Ezhimala covers 131750 ha in the midland of the zone. K31-Panamkutty 108350 ha (soils of Southern Sahyadri) is deep and very deep, well drained loams and clays with fairly high gravel content. K36 soil group covers about 45325 ha (soils of Nilgiri) and is deep or very deep and well drained with loamy to clayey texture and fairly high gravel content (Kerala State Land Use Board, 1997).

3.1. 2. Size of homegardens (HGs)

A variety of social, economic, cultural, ecological, technological and institutional variables determine the given size of the HGs. Out of 16 randomly selected HGs, small HGs represent 68.75%, medium 12.5% and large HGs 18.75%. The mean land holding size (ha) was 0.21, 1.67 and 3.5 in small, medium and large HGs, respectively (Table 3.1.1) The data revealed that the percentage share of HGs to the total cultivated area has increased with increasing landholding size of the farmers.

Table 3.1.1. Size of homesteads

Category	Households encountered (16)		Total land holding size (ha)	Mean land holding size (ha)
	Nos.	Percentage		
Small HGs	11	68.75	2.3	0.21
Medium HGs	2	12.50	2.0	3.34
Large HGs	3	18.75	10.5	3.5

3.1. 3. Classes of HGs

Most of the small HGs were home gardens alone, while medium HGs had both homestead and animal husbandry. Large HGs accommodated animal husbandry and monoculture crops. Small HGs did not hold monoculture plantations while the 4th category was absent in the Southern zone. (Table 3.1.2)

Table 3.1.2. Type of HGs

Type	Number of households encountered		
	Small	Medium	Large
HG alone	9(82%)	1(50%)	-
HG cum monoculture	-	-	1(33%)
HG cum milch animal	2(18%)	1(50%)	2(67%)
HG cum others	-	-	-

3.1.4. Income share of HG and women's role in HG management

It was found that the income share from small HGs was lower than medium and large HGs to the total income. The role of women was more pronounced in the small HGs (Table 3.1.3).

Table 3.1.3.HG's income share and women's role in HG management

Category	Number of households encountered					
	Income share			Women's role		
	<25%	25-50%	>50%	<25%	25-50%	>50%
Small HGs	8 (73%)	3(27%)	-	-	5(55%)	5(45%)
Medium HGs	1(50%)	-	1(50%)	1(50%)	1(50%)	-
Large HGs	-	2(67%)	1(33%)	1(33%)	2(67%)	-

3.1.5. Horizontal structure of HGs

The horizontal arrangement of the components of homegardens seems to vary across the garden size. The coconut (*Cocos nucifera* L.) is a crop, which lends itself to intercropping due to its special growth form, canopy and root characteristics at different growth stages. Sufficient light reaches the understorey of a *Cocos nucifera* L. garden to permit the growth of intercrops except from about the 8^{th} to the 25^{th} year of palm growth (Nair, 1983). The changes of overlapping of the root systems of the *Cocos nucifera* L. palm and the intercrops are minimal as most of the palm roots are found near the bole (Kushwah *et al.* 1973). Coconut palm forms the pillars of the gardens. The land is committed to the *coconut* crop for 80-100 years (life span of tall variety). The coconut palms are planted at a spacing of 5 X 5m or 7.5 X 7.5m apart. However, small and medium farmers do not follow any specific spacing and planting is done according to availability of space. All other crops are arranged relative to the coconut palm. At a glance the arrangement seems haphazard, but a closer scrutiny would reveal that each ensemble occupies a specific niche. About half as many species including *Citrus sp.*, papaya *(Carica pappaya),* etc. were planted only in the interior of the homegardens. Many medium and small-crowned fruit trees such as mango (*Mangifera* indi*c*a L.), jack (*Artocarpus heterophyllus)* and jamun (*Syzygium cumini),* banana (*Musa* sp. Linn) and herbaceous (non-seasonal) perennials and annuals such as turmeric (*Curcuma longa)* and ginger (*Zingiber officinale)* were grown both in the border and the interior parts of the homesteads. The tall trees with large canopy were often placed near the border of the homesteads. Trailing crops like black pepper, yams, beans, etc. are planted close to the trees so as to save production cost on additional trailing materials. However, small fruit trees like jambos, bilimbi, Annona, gooseberry etc. are arranged very close to the home. Ornamental plants are mostly confined to the courtyard, footpath and adjacent areas.

3.1.5.1. Species composition and diversity indices

The mean number of plant species in each functional group of HGs is furnished in Table 3.1.4. The data revealed that of the total 40 encountered plant species, two

species of spices, one annual, 11 fruit crops, six plantation crops, and 19 timber species were included. In this zone, eight common species were recorded. A total of 30, 6 and 4 species were exclusively recorded in small HGs, medium HGs and large HGs, respectively.

Table 3.1.4. Functional class of plants in homesteads

Category	Spices		Annuals		Fruit crops		Plantation crops		Timber species		Medicinal plants	
	*Spp	Density (individuals/ha)	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals/ha)
Small HG	1	33	-		11	1300	6	1133	19	1467	-	-
Medium HG	-	-	-	-	1	67	4	883	8	633	1	17
Large HG	2	66	1	-	1	34	4	64	7	30	-	-
Mean total	2	99	1	-	11	467	6	693.33	19	710	1	5.67

(* Actual species number)

The *Cocos nucifera* L. based farming system incidentally represents a cropping system capable of providing the primary needs of the farmer, besides helping to conserve soil fertility (Singh, 1987). The Javanese homegardens contain about 19 to 24 plant species per garden (Karyono, 1990). In the smallholdings of Kerala a mean number of 13.95 tree species have been reported by Nair and KrishnanKutty (1985). Nair and Sreedharan (1986) have reported 30 arboreal taxa from Kerala homegardens and Babu et al. (1992) observed a total of 36 species of woody perennials from homegardens of Southern Kerala. From the data it was concluded that tree species dominate in all the gardens irrespective of garden size i.e. more than 80% of the total number of species in the garden was constituted by tree species. Thus findings of the present study are comparable with reports of Karyono (1990), Nair and Krishnan Kutty (1985), Nair and Sreedharan (1986) and Babu et al (1992). The number of ornamental species and live-fence species did not vary much across the holdings size groups revealing that the homegardens have almost the same level of aesthetic function for all categories under the study.

The data on diversity indices are provided in Table 3.1.5. Simpson's diversity index (D) was highest in small HGs and lowest in large HGs while Shannon - Wiener's index (H') decreases with increasing HG size.

Table 3.1.5. Species composition and diversity indices of different categories of homegardens

Category	No. of species	Simpson's diversity index (D)	Shannon- Wiener's index (H')
Small	38	0.940	1.403
Medium	14	0.860	0.976
Large	12	0.770	0.817
Total	40*	-	-

(*Common species in HGs: 8)

3.1. 5. 2. Community structure of the HGs

Data on density, basal area, crown area, CLR (Crown Land Ratio) and mean height are furnished in Table 3.1.6. (a, b & c). The high value of mean density (4600 individuals /ha), mean basal area (101.58 m^2/ha) and high mean crown area (45938.39 m^2/ha) were recorded in small HGs. The mean density, mean basal area (m^2/ha) and mean crown area (m^2/ha) of medium and large HGs were 1766.67, 20.63 and 34941.47 and 1633.33, 56.94 and 28166.54 respectively. However, coconut, rubber (*Hevea braziliensis),* arecanut (*Areca catechu W&A.),* banana, jack, mahagony (*Swietenia mahagoni*) and *teak (Tectona grandis)* were dominant species in this zone in terms of density, crown area and basal area. At a glance, the general spatial arrangement shows that most of the small size homegardens were over crowded while none of medium and large HGs was over crowded. Jose (1991) reported that small homegardens have very high tree cropping intensity (890.81 trees/ha) against the large size homegardens. Millat - Mustafa et al. (1996) reported that the maximum number of individuals per hectare varied from 1909 to 2462, 1189 to 2078, 1389 to 2380 and 1754 to 2314 in homegardens of South Western region, North Western region, Eastern and Central Northern region of Bangladesh respectively. Thus the results of the present study are highly incompatible with that of Jose (1991) and Millat - Mustafa et al. (1996). These differences may be due to the fact that small farmers, in spite of small holding size, go for in which high intensive cropping with a keen interest to increase yield to the

maximum extent. Species density and diversity vary in both vertical and horizontal directions of the homegardens. Generally, species density and diversity are high in the nucleus (home) of the homesteads and decreases from nucleus to the boundary of homegardens. This may due to the fact that farmer can provide more care and attention to the nearest surroundings of the homegardens. It was observed that the intensity of management and cultivation of annuals, fruit crops and other vegetables were confined to surroundings of nucleus of homegardens also. The CLR (%) the ratio between canopy and actual land area (ha). was maximum (459.38%) in small HGs followed by medium (349.46%) and large (281.66%). The high value of CLR showed that the degree of overlapping in the canopy in the different stratas of the small HGs was high. It helps to find out gap in the homegardens for further improvement through interventions in the productivity of HGs.

Table 3.1.6. Species diversity, certain biometric parameters and community structure of homegardens

a). Small HGs

Sl. No.	Species	Density (Individuals/ha)	Basal area (m^2/ha)	Crown area(m^2/ha)	CLR (%)	Height (m)
1.	*Acacia mangium*	66.67	2.79	52.33	0.52	16.50
2.	*Achras sapota*	33.33	0.17	26.17	0.26	4.00
3.	*Ailanthus triphysa*	66.67	1.61	471.00	4.71	10.25
4.	*Anacardium occidentale*	33.33	0.05	26.17	0.26	2.50
5.	*Annona squamosa*	100.00	1.36	136.78	1.37	6.50
6.	*Areca catechu*	500.00	2.10	157.00	1.57	10.91
7.	*Artocarpus heterophyllus*	733.33	21.03	15327.47	153.27	10.88
8.	*Artocarpus hirsutus*	133.00	2.53	1988.67	19.88	4.75
9.	*Averrhoa bilimbi*	66.67	0.73	837.33	8.37	6.50
10.	*Azadirachta indica*	33.33	2.55	1674.67	16.75	16.50
11.	*Bombax ceiba*	300.00	17.67	942.00	9.42	15.00
12.	*Bridelia airy-shawii*	66.67	0.00	0.00	0.00	2.50
13.	*Carica papaya*	33.33	0.42	104.67	1.05	4.00
14.	*Caryota urens*	33.33	0.00	654.17	6.54	6.50
15.	*Cinnamomum malabatrum*	33.33	0.42	26.17	0.26	6.00
16.	*Cocos nucifera*	433.33	17.57	8504.17	85.04	10.88
17.	*Coffea arabica*	33.33	0.05	84.78	0.85	6.42

18.	*Elaeocarpus glandulosus*	66.67	0.77	52.33	0.52	7.75
19.	*Emblica officinalis*	33.33	1.70	942.00	9.42	10.50
20.	*Erythrina indica*.	133.33	1.92	418.67	4.19	9.29
21.	*Gliricidia sepium*	66.67	0.45	471.00	4.71	5.25
22.	*Ixora coccinia*	33.33	1.10	418.67	4.19	16.50
23.	*Macaranga peltata*	100.00	0.70	961.63	9.62	5.33
24.	*Mangifera indica*	166.67	1.71	1025.73	10.26	6.60
25.	*Moringa oleifera*	100.00	0.50	78.50	0.79	6.00
26.	*Musa sp.*	432.67	0.69	1177.50	11.78	4.50
27.	*Pavetta indica*	33.33	0.06	26.17	0.26	2.00
28.	*Psidium guajava*	66.67	1.22	0.00	0.00	4.00
29.	Pulinchi	33.33	1.12	0.00	0.00	4.00
30.	*Punica granatum*	33.33	0.11	26.17	0.26	2.50
31.	*Santalum album*	66.67	3.23	837.33	8.37	13.75
32.	*Saraca asoka*	33.33	1.92	654.17	6.54	7.00
33.	*Syzygium aromaticum*	33.33	0.33	104.67	1.05	7.00
34.	*Tabernaemontana heyneana*	33.33	3.57	418.67	4.19	8.50
35.	*Tectona grandis*	33.33	1.12	104.67	1.05	15.50
36.	*Terminalia paniculata*	100.00	3.50	2514.79	25.15	11.00
37.	*Theobroma cocoa*	266.67	1.59	1526.04	15.26	3.82
38.	*Unidentified*	33.33	1.92	1282.17	12.82	9.50
	Total	4600.00	101.58	45938.39	459.38	-

b) Medium HGs

SL. No.	Species	Density (Individuals/ha)	Basal area (m^2/ha)	Crown area (m^2/ha)	CLR (%)	Height (m)
1.	*Ailanthus triphysa*	116.67	0.66	18466.86	184.67	7.43
2.	*Albizia lebbeck*	16.67	0.00	0.00	0.00	0.50
3.	*Areca catechu*	16.67	0.25	13.08	0.131	9.50
4.	*Artocarpus heterophyllus*	66.67	1.91	837.33	8.37	14.12
5.	*Artocarpus communis*	16.67	0.26	13.08	0.131	7.00
6.	*Artocarpus hirsutus*	166.67	3.84	1714.49	17.14	10.37
7.	*Cocos nucifera*	150.00	6.66	3332.61	33.33	12.94
8.	*Hevea braziliensis* .	216.67	0.76	1530.75	15.30	8.46
9.	*Macaranga peltata*	83.33	0.28	261.67	2.62	6.20
10.	*Mangifera indica*	33.33	0.50	320.54	3.20	10.75
11.	*Musa sp.*	500.00	3.58	7257.33	72.57	3.50
12.	*Strychnos nux-vomica*	16.67	0.03	13.08	0.131	4.00
13.	*Tectona grandis*	350.00	1.87	1128.31	11.28	12.04

14.	*Terminalia catappa*	16.67	0.03	52.33	0.52	5.00
	Total	1766.67	20.63	34941.47	349.41	

c) Large HGs

SL.No.	Species	Density (Individuals/ha)	Basal area (m^2/ha)	Crown area (m^2/ha)	CLR (%)	Height (m)
1.	*Ailanthus triphysa*	33.33	0.49	235.50	2.35	8.00
2.	*Areca catechu*	566.67	3.94	444.83	4.4	5.05
3.	*Artocarpus heterophyllus*	169.66	7.13	2342.07	23.44	22.87
4.	*Artocarpus hirsutus*	33.33	1.12	235.50	2.35	11.50
5.	*Bombax ceiba*	33.33	1.70	942.00	9.42	11.00
6.	*Caryota urens*	33.33	2.50	235.50	2.35	18.50
7.	*Cocos nucifera*	500.00	37.77	22551.64	225.51	12.29
8.	*Gliricidia sepium*	66.67	0.12	209.33	2.09	3.00
9.	*Moringa oleifera*	33.33	0.15	104.67	1.05	7.50
10.	*Musa sp.*	100.00	1.07	314.00	3.14	4.00
11.	*Swietenia mahagoni*	66.67	2.04	837.33	8.37	18.00
12.	*Theobroma cocoa*	33.33	0.61	654.17	6.54	6.00
	Total	1633.33	56.94	28166.54	281.66	

3.1. 6. Vertical structure of the HGs

The homegardens have a multi layered canopy structure, which stratified into five strata viz. S0 (< 2 m), S1 (2-7 m), S2 (7-12 m), S3 (12-16 m) and S4 (>16 m). The first layer is up to 2 m from the ground and is constituted by vegetables, tuber crops, grasses and other herbaceous plants. The second and third layers are almost continuous and overlapping each other and major constituents of this layers are rubber, *Musa* sp. Linn., *Eugenia jambos, Psidium guajava, Moringa oleifera*, *Theobroma cacao, Pavetta indica, Punica granatum,* young palms and *Mangifera indica* L.. The fourth layer (12-16 m) consists of *Areca catechu W&A.*, *Cocos nucifera* L., *Artocarpus heterophyllus* and *Mangifera indica* L. The top layer (>16 m) predominantly consisted of tallest trees of *Cocos nucifera*, *Areca catechu* and *Artocarpus heterophyllus*, but few in number. This study reveals that high density, basal area and crown area were recorded in S2 of small HGs. Maximum density and crown area of medium HGs were recorded in S1 and S2 whereas mean basal area was

recorded in S3 of medium HGs. In case of large HGs, high value of basal area was noted in S3 and high mean density and crown area were recorded in S1and S2, respectively (Table 3.1.7. a, b & c). The maximum value of basal area and crown area was recorded in S0 stratum in the small HGs. The high value of density, basal area, and crown area were recorded in S1stratum in both medium HGs and large HGs. In the five layered Javanese homegardens, 13.59% of the canopy size is constituted by the lowest layer, 8.87%, 25.11%, 36.12% and 16.31% by the second, third, fourth and fifth layers respectively (Soemarwoto and Soemarwoto, 1982). Traditional village gardens with 200% crown coverage have been reported from west Java (Michon and Mary, 1990). The stratified structure of the garden together with litter and ground layer has significant conservation value as it can effectively reduce soil erosion due to rain and wind splash erosion in the homegarden in not more than 80% of that in an open space (Ambar, 1986). Thus the findings of this study was highly compatible with the above mentioned authors view.

Table 3.1.7.Vertical structure of homesteads

a) Small HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16 m)
Mean density (individuals/ha)	33.33	1986.6	2066.67	400.00	133.00
Mean basal area (m^2/ha)	0.06	18.83	57.25	27.02	8.43
Mean crown area (m^2/ha)	26.17	13791.53	28463.14	1884.00	2145.67

b) Medium HGs

Parameter	Strata				
	S0 (<2 m)	S1(2-7 m)	S2 (7-12 m)	S3(12-16 m)	S4(>16 m)
Mean density (individuals/ha)	16.67	650.00	550.00	400.00	-
Mean basal area (m^2/ha)	-	4.18	6.01	10.44	-
Mean crown area (m^2/ha)	-	7597.49	22045.73	5298.25	-

c). Large HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16 m)
Mean density (individuals/ha)	-	766.67	266.67	100.00	-
Mean basal area (m^2/ha)	-	5.74	8.89	42.31	-
Mean crown area (m^2/ha)	-	1622.33	2919.74	1072.83	-

3.2. Central zone

3.2.1.General features

This zone of Kerala comprises districts of Ernakulam, Thrissur and Palakkad. It lies between latitudes 9°49' N and 11°16' N and between longitudes 75 °62' E and 76 °50' E. The total geographical area of the zone is 743360 ha and population 5999233 accounting for 19.13% and 20.62% of total area and total population of State, respectively. The percentage of literacy of the zone is 88.17. The altitude of the zone varies between 7.5 m and 750 m. The central zone being situated on the windward side of the Western Ghats and falling within the direct sweep of South-West monsoon receives heavy rainfall. Ernakulam district received the highest average rainfall (3550 mm), followed by Thrissur district (3215 mm). The temperature variations between Ernakulam and Thrissur are only marginal whereas in Palakkad district the temperature variations are more pronounced. The mean maximum temperature of the zone varies from 24.8 °C to 31.4 °C and minimum temperature from 21.1 °C to 23.1 ° C. The mean relative humidity is as high as 82% and average annual relative humidity is around 70% but in Palakkad it is around 40% during December-March. The number of rainy days in a year is 172. The predominant soils are K07-Airapuram-Nedumpara, which cover 71175 ha in lowland of the zone, excessively drained to moderately drained soil and have sandy to clayey textures. K10 (Kondotty Nedumpara) covers 68975 ha and K11 (Kondotty) covers 12225 ha. These are very deep, well drained gravelly clay soils in midland of the zone. Soils of central Sahyadri are K16 Chambarakulam - Kalanthode (54900 ha) and K17 (Ambalamade-Karanthode (75475 ha) which are deep moderately drained and clayey with high gravel and land laterite. Thus about 426100 ha (56.09%) are very deep to deep and 84050 ha (11.06%) are very deep soil out of the total soils of the zone. About 34.09% soils of the zone are loamy to clayey in nature. About 33% of area of the zone is not suitable for irrigation.

About 80% of the population in the zone is directly dependant on agriculture. The land retains and other legislative measures initiated in the state are reflected in the fragmentation of agricultural holdings. More than 92.72% of the holdings are less

than a hectare. Holdings of size more than 4 ha account for only 0.46%. The zone has a comparatively high cattle population and a good number of farmers rear cattle for milk, cattle manure and as draught animals for field operations. Fishing is the major occupation of the people in the coastal area of zone. The area of forest cover and net crop grown are 204959 ha (18.9%) and 422653 ha (18.79%) respectively.

3. 2.2. Size of homegardens (HGs)

A variety of social, economic, cultural, ecological, technological and institutional variables determine the given size of the homegardens (HGs). Out of 40 randomly selected HGs, small HGs represent 48.2%, medium 37.5% and large 14.3% (Table 3.2.1.). This difference may due to continuous fragmentation of land. The data revealed that the percentage share of HGs to the total cultivated area has increased with increasing landholding size of the farmers.

Table 3.2.1. Size of HGs

Category	Households encountered		Total land holding size (ha)	Mean land holding size (ha)
	Nos.	Percentage		
Small HGs	19	48.20	3.52	0.18
Medium HGs	15	37.50	10.7	0.71
Large HGs	6	14.30	10.64	1.77

3.2. 3. Classes of HGs

Small HGs were made of homegardens alone and homegardens with animals while medium HGs were made of homegardens alone, homegarden with animals and homegardens with apiculture. However, large HGs had only homegarden with monoculture and homegarden cum milch animal. (Table 3.2.2).

Table 3.2.2. Type of homegardens

Type of HGs	Number of households encountered (40)		
	Small HG	Medium HG	Large HG
Homegarden alone	10(53%)	4(26%)	-
Homegarden cum monoculture	-	-	4(67%)
Homegarden cum milch animal	9(47%)	10(67%)	2(33%)
Homegarden cum others (Sericulture/ Apiculture)	-	1(7%)	-

3.2.4. Income share of HGs and women's role in HGs management

Income share from HGs to total income was highest in large HGs and lowest in small HGs. Women's role in HG management was well pronounced in small HGs. (Table 3.2.3).

Table 3.2.3. Homestead's income share and women's role in homestead management

Category	Number of households encountered					
	Income share			Women's role		
	<25%	25-50%	>50%	<25%	25-50%	>50%
Small HGs	12(63%)	7(37%)	-	6(32%)	4(21%)	9(47%)
Medium HGs	7(47%)	6(40%)	2(13%)	9(53%)	4(27%)	3(20%)
Large HGs	-	2(33%)	4(67%)	3(50%)	1(33%)	1(17%)

3.2. 5. Horizontal structure of HGs

3.2. 5. 1. Species composition in HGs

The mean numbers of plant species in functional group is furnished in Table 3.2.4. Out of six groups, timber group is predominant one, which represents 10 species.

Table 3.2.4. Functional class of plants in HGs

Category	Spices		Annuals		Fruit crops		Plantation crops		Timber species		Medicinal plants	
	*Spp	Density (individuals/ha)	*Spp	Density (individuals/ha)	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals/ha)
Small HGs	2	34	4	505	7	194	6	1767	6	497	2	8
Medium HGs	1	92	3	1183	6	219	6	1346	5	467	4	151

Large HGs	2	59	2	17	5	333	5	2441	4	395	1	17
Mean total	3	62	4	568	8	249	7	1851	10	453	5	59

(* Shows actual species number)

The data on species composition and diversity indices (Table 3.2.5) revealed that of total 26 encountered plant species, total 15 were common species in all three classes of HGs. A total of 12, 10 & 4 species were exclusively recorded in small HGs, medium HGs and large HGs, respectively. The data on diversity indices indicate that highest mean Simpson's diversity index (D) and Shannon- Wiener diversity index (H') were recorded in medium and large HGs respectively. The higher value of H' indicates that flora of large farms was more stable than others. Compared with southern zone, diversity is low in this zone.

Table 3.2.5. Species composition and diversity indices in HGs

Sl. No.	Class	No. of species	Simpson's diversity index (D)	Shannon- Wiener's index (H')
1	Small HGs	27	0.749	0.90
2	Medium HGs	25	0.840	0.69
3	Large HGs	19	0.662	0.98
	Total	26		

(Common species in small, medium and large HGs**:** 15)

3.2. 5. 2. Community structure of the HGs

Data on mean density, basal area, crown area, CLR (Crown Land Ratio) and mean height are furnished in table 3.2.6. (a, b & c). The high mean density (3302 individuals / ha) and mean basal area (71.54 m^2/ha) were noted in medium and large HGs respectively, whereas high mean crown area (47705.50 m^2/ha) was recorded in large HGs. Low mean density and mean basal area (m^2/ha) and mean crown area (m^2/ha) were in small HGs. In general, *Cocos nucifera, Musa sp., Areca catechu., Hevea braziliensis, Artocarpus and Mangifera indica* were dominant species in all categories of homegardens in terms of density, crown area and basal area. The data on CLR (%) revealed that the maximum CLR (477.05%) was recorded in large HGs followed by medium (181.83%) and small (211.15%). The high value of CLR showed that the

degree of overlapping in the canopy in the different strata of the homegardens. It helps to find out gap in the homegardens for further improvement through interventions in the productivity of HGs. The large HGs have shown high value in terms of CLR (%) because large farmers have more inputs, land area and high dependency on farming.

Table 3.2.6 (a. b & c). Species diversity, certain biometric parameters and community structure of homegardens

a) Small HGs

Sl. No.	Species	Density (individuals/ha)	Basal area (m^2/ha)	Crown area (m^2/ha)	CLR (%)	Mean height (m)
1.	*Ailanthus triphysa*	66.67	0.02	52.33	0.52	7.50
2.	*Anacardium occidentale*	5.50	0.00	276.32	2.76	8.50
3.	*Ananas comosus*	100.00	0.00	0.00	0.00	0.00
4.	*Annona squamosa*	25.00	0.05	19.63	0.20	11.50
5.	*Areca catechu*	1400.00	12.08	1099.00	10.99	13.50
6.	*Artocarpus communis*	22.17	0.07	156.61	1.57	8.50
7.	*Artocarpus heterophyllus*	108.33	0.50	2126.04	21.26	12.50
8.	*Bombax ceiba*	5.50	0.00	4.32	0.04	8.50
9.	*Capsicum frutescens*	16.67	0.00	2.09	0.02	0.25
10.	*Carica papaya*	22.17	0.03	17.40	0.17	7.50
11.	*Caryota urens*	16.67	0.01	52.33	0.52	10.50
12.	*Cocos nucifera*	297.17	13.85	9855.90	98.56	12.50
13.	*Coffea arabica*	5.50	0.01	69.08	0.69	7.00
14.	*Emblica officinalis*	8.33	0.00	58.88	0.59	7.50
15.	*Garcinia gummi-gutta*	8.33	0.00	58.88	0.59	6.00
16.	*Gliricidia sepium*	50.00	0.01	353.25	3.53	7.50
17.	*Hevea braziliensis*	58.33	0.02	732.67	7.33	8.50
18.	*Lannea coromandelica*	33.33	0.01	26.17	0.26	4.50
19.	*Macaranga peltata*	83.33	0.04	588.75	5.89	12.50
20.	*Mangifera indica*	50.00	0.21	981.25	9.81	9.50
21.	*Manihot esculenta*	8.33	0.00	3.21	0.03	1.50
22.	*Musa sp.*	380.50	2.38	3658.98	36.59	5.50
23.	*Myristica fragrans*	16.67	0.00	327.08	3.27	5.50
24.	*Swietenia mahagoni*	100.00	0.10	314.00	3.14	10.00
25.	*Syzygium aromaticum*	16.67	0.01	52.33	0.52	5.50
26.	*Tamarindus indica*	25.00	0.02	176.63	1.77	11.50
27.	*Tectona grandis*	66.67	0.04	52.33	0.52	11.50
	Total	2996.83	29.45	21115.45	211.15	

b). Medium HGs

SL. No.	Species	Density (individuals/ ha)	Basal area (m^2/ha)	Crown area (m^2/ha)	CLR (%)	Mean height (m)
1.	*Ailanthus triphysa*	8.33	0.002	1.679	0.02	6.00
2.	*Anacardium occidentale*	58.33	0.310	367.605	3.68	8.50
3.	*Annona squamosa*	25.00	0.013	16.490	0.16	6.50
4.	*Areca catechu*	616.67	1.591	1344.676	13.45	10.50
5.	*Artocarpus heterophyllus*	93.33	0.048	24.931	0.25	9.00
6.	*Carica papaya*	16.67	0.007	5.815	0.06	5.50
7.	*Caryota urens*	16.67	0.021	1.454	0.01	9.00
8.	*Cocos nucifera*	508.33	24.729	24485.640	244.86	12.50
9.	*Coffea arabica*	166.67	0.030	3.634	0.04	3.50
10.	*Curcuma longa*	0.00	0.000	0.000	0.00	0.00
11.	*Emblica officinalis*	16.67	0.004	17.808	0.18	7.00
12.	*Garcinia gummi-gutta*	16.67	0.003	0.363	0.00	3.50
13.	*Gliricidia sepium*	108.33	0.414	2.362	0.02	6.50
14.	*Hevea braziliensis*	25.00	0.015	8.722	0.09	8.00
15.	*Lannea coromandelica.*	33.33	0.007	0.727	0.01	7.00
16.	*Macaranga peltata*	50.00	0.044	1.090	0.01	6.50
17.	*Malus pumila*	183.33	0.000	0.000	0.00	0.00
18.	*Mangifera indica*.	75.00	0.900	865.135	8.65	12.50
19.	*Moringa oleifera*	8.33	0.003	0.727	0.01	6.50
20.	*Murraya koenigii*	66.67	0.026	52.333	0.52	8.50
21.	*Musa. Paradisiaca*	1000.00	4.428	4648.072	46.48	3.50
22.	*Myristica fragrans*	25.00	0.005	8.722	0.09	3.00
23.	*Psidium guajava*	8.33	0.006	1.635	0.02	6.00
24.	*Tectona grandis*	175.00	1.219	747.931	7.48	11.50
25.	*Zingiber officinalis*	0.00	0.000	0.000	0.00	0.00
	Total	3301.67	33.824	32607.554	326.07	

c). Large HGs

SL.No.	Species	Density (individuals/ha)	Basal area (m^2/ha)	Crown area (m^2/ha)	CLR (%)	Mean height (m)
1.	*Albizia lebbeck*	8.33	0.95503	418.4992	4.18	10
2.	*Areca catechu*	1750	20.6524	34343.75	343.43	8.5
3.	*Artocarpus communis*	224.17	34.9813	2155.636	21.55	15
4.	*Averrhoa bilimbi*	8.33	0.06791	163.4763	1.63	6
5.	*Carica papaya*	66.66	0.47766	52.3281	0.52	4.5

6.	*Cocos nucifera*	8.33	0.39834	235.4058	2.35	13.5
7.	*Coffea arabica*	600	3.88018	4239	42.39	3.5
8.	*Garcinia gummi-gutta*	16.66	0.29301	836.9984	8.37	7
9.	*Gliricidia sepium*	16.66	0.13162	13.0781	0.131	3.5
10.	*Hevea braziliensis*	83.33	1.62563	588.7265	5.89	7.5
11.	*Macaranga peltata*	8.33	0.14034	320.4135	3.20	5
12.	*Manihot esculenta*	8.33	0	0	0	1.5
13.	*Moringa oleifera*	16.66	0.53485	836.9984	8.37	7.5
14.	*Musa sp.*	8.33	0.07005	104.6248	1.05	3.5
15.	*Myristica fragrans*	16.66	0.14445	640.8269	6.41	6
16.	*Piper nigrum*	41.66	0	0	0.00	
17.	*Swietenia mahagoni*	16.66	0.55183	1307.81	13.08	8.5
18.	*Tamarindus indica*	100	4.18491	1256	12.56	9.5
19.	*Tectona grandis.*	244.5	2.45327	191.9325	1.92	9.5
	Total	3243.6	71.5428	47705.5		

3.2. 6. Vertical structure of the HGs

Among the 5 strata of the small HGs, S3 showed highest mean density, basal area (m2/ha) and crown area, while for medium HGs S1 was highest for density while S3 was for basal area and crown area. In large HGs density and crown area were highest in S2 and basal area was in S4 stratum (Table 3.2.7.a.b&c).

Table 3.2.7. Vertical structure of homesteads

a) Small HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16 m)
Mean density (individuals/ha)	125	461.00	522.00	1888.83	-
Mean basal area (m^2/ha)	0.00	2.41	0.58	26.47	-
Mean crown area (m^2/ha)	5.30	4192.52	3247.05	13669.69	-

b).Medium HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16 m)
Mean density (individuals/ha)	183	1475	477	583	617
Mean basal area (m^2/ha)	0.00	4.958	1.614	25.629	1.591
Mean crown area (m^2/ha)	0.00	4690.00	1169.00	25350.77	1344.68

b) Large HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16 m)
Mean density (individuals/ha)	50	725	19912	8.00	469
Mean basal area (m^2/ha)	-	4.912	28.798	0.398	37.435
Mean crown area (m^2/ha)	-	5533.75	39588.78	235.406	2347.569

3.2.7. Interventions in the agroforestry systems

One hundred and twenty six plant species were distributed to farmers in central zone. Farmers were suggested five types of interventions viz., introduction of annual crops, introduction of multi-purpose timber trees (MPTs), introduction of medicinal plants, introduction of fruit crops and introduction of plantation/ cash crops for enhancing the productivity of homegardens. A total of 1069 seedlings of 113 species (Appendix-2) were distributed to the 35 households as intervention to develop new agroforestry models. Of 1069 plants, 26, 198, 34, 217, 154 and 361 plants of annuals, fruit crops, medicinal plants, plantation crops spices and tee species were distributed to farmers of the zone, respectively (Table 3.2.8.a,b & c). The survival percentage after 8 months planting was about 82% (Plate 1-6).

Table 3.2.8. Interventions for new agroforestry models

a) Small HGs

SL. No.	Type of Intervention	No.of species	Quantity (No.)	Households (No.)
1	Annuals	4	20	19
2	Fruit trees	16	91	55
3	Medicinal plants	8	16	10
4	Plantation crops	4	123	17
5	Spices	3	67	14
6	Trees	10	79	19
	Total	45	475	134

b) Medium HGs

SL. No.	Type of Intervention	No. of species	Quantity (No.)	Households (No.)
1.	Annuals	2	3	3
2.	Fruit trees	12	67	34
3.	Medicinal plants	4	10	4
4.	Plantation crops	4	45	7
5.	Spices	4	39	10
6.	Trees	11	156	23
	Total	37	320	81

c). Large HGs

SL. No.	Type of Intervention	No. of species	Quantity (No.)	Households (No.)
1.	Annuals	3	3	3
2.	Fruit trees	12	40	19
3.	Medicinal plants	2	8	2
4.	Plantation crops	3	49	5
5.	Spices	3	48	14
6.	Trees	8	126	5
	Total	31	274	48

3.3.Northern zone

3.3.1. General features

The northern zone consists of four northern districts of Kerala state viz. Malappuram, Kozhikode, Kannur and Kasargod. It is located between $10^{o}30'$ and $12^{o}48'$ N latitudes and between $74^{o}52'$ and $76^{o}30'$ E longitudes. The total population of the zone is 8796754 (1991 census), which accounts for 30.23% of state's population. The zone enjoys a tropical climate. The mean annual rainfall of the zone is 3378 mm with minimum rainfall of 2800 mm in Northeastern parts of Malappuram and the maximum of 4000 mm in the high ranges of Kozhikode and Kannur districts. The mean maximum and minimum temperatures are 33 ^{o}C and 24 ^{o}C respectively. The entire zone is highly humid throughout the year, the maximum and minimum percentage being 96 during S-W monsoon and 51 in summer.

The zone has a geographical area of 10610.10 sq. km, which is 27.31% of the area of the state. The grass cropped area of the zone is about 872641 ha (28.64%). The net area sown is 701294 ha. The number of operational holdings in the zone according to 1991 census is 14.49 lakhs, which accounts for 26.29% in the state. The majority of the holdings (89.09%) fall within the range of 0.02 ha to 0.99 ha. Only about 0.04% of the holdings have an area of more than 10 ha.

Predominant soil is K07 (Airapuram Nedumpara), which covers 69025 ha, is excessively drained to moderately well drained and has sandy to clayey textures in low land of the zone. The predominant soil types are K09 (Ramanthali Ezhimala), K10 (Kondotty-nedumpara) and K13 (Kunhipara) and K20 (Alakkode Kanivara), K22 (Karivara-Panamkutty) and K24 (medium) in midland and central Sahyadri, respectively. These soil types are deep, moderately well drained, clayey with high gravel content, hard laterite with rock outcrops.

About 85% of the population in the zone is engaged in farming and allied activities. The average size of land holdings varies from 0.26 ha in Kozhikode to 0.65 ha in Wayanad district. The major cropping systems adopted in the Northern zone are: a) Rice based cropping system, b) Coconut based cropping system and c) Homestead

farming system, which is an unique feature of the state and is adopted in all the physiographic divisions in the zone.

3.3. 2. Size of HGs

Out of 23 randomly selected HGs, small HGs represent 21.74%, medium 26.09% and large 52.17% (Table 3.3.1.). The data revealed that large HGs representation was high. This difference may due to most of the families are joint family, land value is low and most of the farmers migrated from southern part of the State, Kerala, who are comparatively rich than natives of the region.

Table 3.3.1. Size of HGs

Category	Households encountered		Total land holding size (ha)	Mean land holding size (ha)
	Nos.	Percentage		
Small HGs	5	21.74	0.99	0.20
Medium HGs	6	26.09	2.92	0.49
Large HGs	12	52.17	35.0	2.92

3.3. 3. Classes of HGs

The data revealed that small HGs had first three classes while medium and large HGs had homestead with monoculture and homestead with milch animal class (Table 3.3.2.). This difference may be due to the locality factors, local market and farmer's interest. A typical characteristic of homegardens of the zone is rubber can be cultivated in all size of homesteads irrespective of land holding size and income.

Table 3.3. 2. Type of HGs

Type	Number of households encountered		
	Small	Medium	Large
Homestead alone	2(40)	-	-
Homestead cum monoculture	1(20)	3(50)	2(17)
Homestead cum milch animal	2(40)	3(50)	10(83)
Homestead cum others		-	

(Parenthesis value show percentage)

3.3.4. Income share of HGs and women's role in HGs management

Regarding income share from HGs to the total income, about 80% of small HGs would receive <25% income while 50% medium and 75% of large HGs would get 25-50% and >50% income share from HGs respectively. In case of role of women in the management of HGs, maximum women's role was recorded in small HGs followed by medium HGs and lowest was in large HGs (Table 3.3.3.).

Table 3.3.3. Homestead's income share and women's role in HGs management

Category	Number of households encountered					
	Income share			Women's role		
	<25%	25-50%	>50%	<25%	25-50%	>50%
Small HGs	4(80)	1(20)	-	1(20)	3(60)	1
Medium HGs	20(33)	3(50)	1(17)	3(50)	3(50)	-
Large HGs	-	3(25)	9(75)	6(50)	2(17)	4 (33)

(Parenthesis value show percentage)

3.3.5. Horizontal structure of HGs

The horizontal arrangement of the components of the homegardens seems to vary across the garden size like in other zones. The *Cocos nucifera* L. is a crop which lends itself to intercropping due to its special growth form, canopy and root characteristics at different growth stages. The characteristics of coconut already were described in 3.1.5. Small and medium farmers were not following any specific spacing and planting to be done according to availability of space.

3.3.5. 1. Species composition in HGs

The data on mean numbers of plant species of functional group are given in Table 3.3.4. The data revealed that out of total 26 encountered plant species, seven were common species in this zone. A total of 4, 8 and 14 species were exclusively recorded in small HGs, medium HGs and large HGs, respectively. The mean number of species of six functional groups is 2 species belonging to annuals, 7 fruits, 4 plantation, 9 timber, 1 spices and 3 medicinal.

Table 3.3.4. Functional classification of plants in HGs

Category	Spices		Annuals		Fruits		Plantation crops		Timber crops		Medicinal plants	
	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals/ha)
Small HGs	-	-	1	100	2	400	3	1900	5	800	-	-
Medium HGs	-	-	1	500	6	600	4	1400	3	250	1	50
Large HGs	1	50	2	84	5	301	4	600	8	334	3	17
Total mean	1	16	2	228	7	434	4	1300	9	461	3	22

(* Actual species number)

The data on various diversity indices are shown in table 3.3.5. High Simpson's diversity index (D) and Shannon Weiner diversity index (H') were recorded in large HGs.

Table 3.3.5. Species composition and diversity indices

Category	No. of species	Simpson's diversity index (D)	Shannon-Wiener's index (H)
Small HGs	11	0.723	0.7902
Medium HGs	15	0.874	1.011
Large HGs	21	0.898	1.1346
Total	26		

(Common species in small, medium and large: 7)

3. 3.5. Community structure of HGs

Data on density, basal area, crown area, CLR (Crown Land Ratio) and mean height are given in table 3.3.6. (a, b & c). The high mean density (3200 individuals /ha) and mean basal area (63.19 m^2/ha) were recorded in small HGs while highest mean crown area (18591.42 m^2/ha) was recorded in large HGs. The low value of mean density (1416.67/ha) and mean basal area (31.06 m^2/ha) were recorded in large HGs where as low crown area (15741.57) was recorded in small HGs. However, *Cocos nucifera* L. *Areca catechu W&A., Hevea braziliensis, Anacardium occidentale, Macaranga peltata (Roxb.) Musa sp., Terminalia paniculata, Artocarpus heterophyllus and*

Mangifera indica were dominant species in all categories of homegardens in terms of density, crown area and basal area. The data CLR (%) revealed that the maximum CLR (185.91%) was recorded in large HGs followed by medium (181.83%) and small HGs (157.42%). The large HGs has showed high value in terms of CLR (%) because plants of large HGs had sufficient space for growth and development and high managerial inputs which supplied by rich large farmers.

Table 3.3.6 (a, b & c). Species diversity, certain biometric parameters and community structure of homegardens

a). Small HGs

Sl. No	Name of species	Density (Individuals /ha)	Basal area (m2/ha)	Crown area (m2/ha)	CLR (%)
1.	*Macaranga peltata*	200.00	2.18	628.00	6.28
2.	*Mangifera indica*	200.00	15.61	3925.00	39.25
3.	*Areca catechu*	1600.00	27.62	1690.07	16.90
4.	*Cocos nucifera*	200.00	7.36	628.00	6.28
5.	*Terminalia paniculata*	200.00	1.68	3925.00	39.25
6.	*Pterocarpus marsupium*	100.00	1.47	78.50	0.79
7.	*Tectona grandis*	100.00	0.10	1962.50	19.63
8.	*Erythrina indica*	200.00	3.01	1413.00	14.13
9.	*Musa sp.*	100.00	0.42	1256.00	12.56
10.	*Anacardium occidentale*	100.00	2.26	78.50	0.79
11.	*Artocarpus heterophyllus*	200.00	1.48	157.00	1.57
	Total	3200.00	63.19	15741.57	157.42

b). Medium HGs

Sl. No.	Species	Density (Individuals/ha)	Basal area (m^2/ha)	Crown area (m^2/ha)	CLR (%)
1.	*Areca catechu*	600.00	7.08	471.00	4.71
2.	*Ailanthus triphysa*	100.00	1.03	314.00	3.14
3.	*Garcinia gummi-gutta*	50.00	0.42	353.25	3.53
4.	*Strychnos nux-vomica*	50.00	0.25	39.25	0.39
5.	*Cocos nucifera*	450.00	16.08	8831.25	88.31
6.	*Hevea braziliensis*	100.00	1.03	706.50	7.07

7.	*Anacardium occidentale*	250.00	6.81	4906.25	49.06
8.	*Psidium guajava*	50.00	0.70	157.00	1.57
9.	*Musa sp.*	500.00	3.58	392.50	3.93
10.	*Artocarpus heterophyllus*	150.00	3.81	471.00	4.71
11.	*Achras sapota*	50.00	0.40	88.31	0.88
12.	*Mangifera indica*	200.00	7.69	628.00	6.28
13.	*Embilica officinalis*	100.00	1.44	706.50	7.07
14.	*Santalum album*	50.00	0.18	39.25	0.39
15.	*Erythrina indica*	100.00	0.84	78.50	0.79
	Total	2800.0	51.35	18182.56	181.83

c) Large HGs

Sl. No.	Species	Density (Individuals /ha)	Basal area (m^2/ha)	Crown area (m^2/ha)	CLR (%)
1.	*Achras sapota*	166.67	0.43	130.83	1.31
2.	*Ailanthus triphysa*	16.67	0.37	117.75	1.18
3.	Alston*ia scholaris*	16.67	0.03	52.33	0.52
4.	*Anacardium occidentale*	100.00	4.32	6358.50	63.59
5.	*Areca catechu*	16.67	0.12	13.08	0.13
6.	*Artocarpus heterophyllus*	33.33	1.41	104.67	1.05
7.	*Cica disticha*	16.67	0.28	837.33	8.37
8.	*Cocos nucifera*	216.67	13.97	4252.08	42.52
9.	*Erythrina indica*	166.67	1.87	523.33	5.23
10.	*Garcinia gummi-gutta*	16.67	0.10	117.75	1.18
11.	*Hevea braziliensis*	266.67	6.03	5233.33	52.33
12.	*Musa sp.*	16.67	0.08	117.75	1.18
13.	*Bombax ceiba*	16.67	0.49	209.33	2.09
14.	*Ananas comosus*	66.67	0.00	0.00	0.00
15.	*Piper nigrum*	83.33	0.00	0.00	0.00
16.	*Psidium guajava*	33.33	0.00	26.17	0.26
17.	*Santalum album*	16.67	0.06	13.08	0.13
18.	*Gliricidia sepium*	33.33	0.17	104.67	1.05
19.	*Chrysophyllum cainito*	16.67	0.17	13.08	0.13
20.	*Strychnos nux-vomica*	16.67	0.10	13.08	0.13
21.	*Tabernaemontana heyneana*	16.67	0.09	13.08	0.13
22.	*Terminalia paniculata*	50.00	0.50	157.00	1.57
	Total	1416.67	31.06	18591.42	185.91

3.3. 6. Vertical structure of the homegardens

This study reveals that both high density and basal area were recorded in S3 of small HGs while high crown area was recorded in S1 of the same. The maximum density, crown area and mean basal area of medium HGs were recorded in S3. In case of large HGs, the high value of basal area and crown area were noted in S3 and its high mean density was recorded in S1 stratum (Table 3.3.7a,b & c).

Table 3.3.7. Vertical structure of homesteads

a) Small HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16 m)
Mean density (individuals/ha)	400	600.00	400.00	1800.00	-
Mean basal area (m^2/ha)	3.37	6.22	18.62	34.98	-
Mean crown area (m^2/ha)	1491.5	6594.00	5338.00	2318.07	-

b) Medium HGs

Parameter	Strata				
	S0 (<2m)	S1 (2-7m)	S2 (7-12m)	S3 (12-16)	S4 (>16m)
Mean density (individuals/ha)	-	950.00	800.00	1850.00	-
Mean basal area (m^2/ha)	-	7.81	20.37	43.53	-
Mean crown area (m^2/ha)	-	1854.56	7025.75	16328.00	-

c). Large HGs

Parameter	Strata				
	S0 (<2m)	S1 (2-7m)	S2 (7-12m)	S3 (12-16)	S4 (>16m)
Mean density (individuals/ha)	183.34	566.7	450.00	216.67	-
Mean basal area (m^2/ha)	0.38	4.67	12.03	13.97	-
Mean crown area (m^2/ha)	235.5	2184.89	119.20	4252.08	-

3.4. High range agroclimatic zone

3.4.1. General features

The high range zone is a sub division of the Western Ghats with an elevation above 750 m from msl and comprises districts of Wayanad and Idukki, Nelliampathy and Attappady hill ranges of Palakkad district, Thannithode and Seethathode Panchayat of Pathanamthitta district, Aryankavu, Kulathupuzha and Thenmala panchayats of Kollam districts and Peringamala, Vithura, Aryanad, Kallikkad and Amboori Panchayats of Trivandrum district. The total population of the zone is (as per 1991 census) 31,86,367, which accounts for 10.95% of the total state population. Wayanad lies between 11^{o}26' and 11^{o}59' N latitudes and 76^{o}96' and 76^{o}46'E longitudes Idukki lies between 9^{o}16' and 10^{o}22'N latitudes and 76^{o}36' and 77^{o}25'E longitudes. The altitude of high ranges is above 750 m from msl. Out of total geographical area (957050), the area of forest cover and net sown area are 496365 ha (41.27%) and 405017 ha (18%) respectively. Mild-sub tropical climate prevails in this zone, which is conducive for growing both sub tropical and tropical crops. The mean average rainfall of Wayanad is 2322 mm while that of Idukki is 3090 mm. High velocity wind and severe cold are common in this zone. The mean temperature ranges are 25^{o}-27^{o}C and 5^{o}-15^{o}C respectively. The mean annual relative humidity is 76.8%.

The predominant soils are K18-Karivara-Meduni (139375 ha), K37-Udumbanchola-Medura (55025 ha), K38-Udumbanchole (9217325 ha) which are deep and very deep, well-drained loam and clayey with fairly high gravel content and K36 (soils of Nilgiris) covers with area of 260800 ha in the zone.

The total number of households in the zone is 649003, which accounts for 11.77% of total number in the State. Unlike other zones, only 86.83% of the total holdings in the zone came under the holding size between 0.02 to 1.00 ha. This is because of the large number of plantation crop holdings in the high range zone. The population density varies from 17 in Nelliampathy to 1040 in Vannapuram. The Scheduled Castes and Scheduled Tribes constitute 13 and 55% of the total population in the zone. This zone is characterized by the cultivation of perennial crops and spices. Coffee based farming

system is the notable feature of Wayanad. The total area under coffee in the zone is 82348 ha which accounts 15.29% of the total cropped area in the zone. The other major crops are tea (3172 ha) cardamom (38348 ha), rubber (63015 ha), coconut (59954 ha) cassava and ginger. The predominance of forests and the grass lands in the high altitude region is congenial for the development of cattle wealth which accounts for 15.98% and 16.55% of total livestock population in the zone and in the state respectively (KSLUB, 1997).

3.4. 2. Size of HGs

Out of 40 randomly selected HGs, small HGs represent 42%, and medium 37 % and large HGs 21% (Table 3.4.1.). The data revealed that the percentage share of HGs to the total cultivated area has increased with increasing land-holding size of the farmers.

Table 3. 4.1. Size of homesteads in high range zone

Category	Households encountered		Total land holding size (ha)	Mean landholding size (ha)
	Nos.	Percentage (%)		
Small HGs	17	42	3.23	0.22
Medium HGs	15	37	7.18	0.55
Large HGs	8	21	16.24	2.03

3.4. 3. Classes of HGs

The data revealed that both small and medium HGs had homestead only and homestead with monoculture, while large HGs had homestead monoculture and homestead with livestock classes.

Table 3.4.2. Type of homesteads in high range zone

Type	Number of households encountered (40)		
	Small HG	Medium HG	Large HG
Homestead alone	14(82)	10(67)	-
Homestead cum monoculture	-	-	07(87.5)
Homestead cum milch animal	03(18)	05(33)	08(12.5)

Homestead cum others (sericulture/ Apiculture etc.)	-	-	-

(Values in the parenthesis shows percentage)

3.4. 4. Income share of HGs and women's role in HGs management

Data provided in the table 3.4.3 shows that medium HGs contributed more to the total income of homesteads. Women's role in management was more in small HGs and least in large HGs.

Table 3.4.3. Homestead's income share and women's role in homestead management

Category	Number of households encountered					
	Income share			Women's role		
	<25%	25-50%	>50%	<25%	25-50%	>50%
Small HGs	3 (18)	10 (59)	4 (23)	1(6)	4(23)	12(71)
Medium HGs	2 (13)	7 (47)	6 (40)	1(7)	3(20)	11(73)
Large HGs	2(26)	3(37)	3(37)	3(37)	4(50)	1(13)

(Values in the parenthesis show percentage)

3.4. 5. Horizontal structure of HGs

3.4. 5. 1. Species composition and diversity indices

Based on the major function of plant, the recorded plants were grouped in to six different groups. The mean number of plant species of function was furnished in the Table 3.4.4. Among six groups, plantation and timber group are predominant with density of 1711 belonging to 8 species and 1602 plants to 6 species respectively. The study revealed that total of 29 plant species were encountered from HGs. Out of 29 species 7 were common species in all three classes of HGs. A total of 8, 17 and 6 species were exclusively recorded in small HGs, medium HGs and large HGs, respectively. It was concluded from the data that most of the small farmers preferred annual crops, medium farmers both plantation crops and timber species equally and large farmers were preferred more timber species than other crops.

Table 3. 4. 4. Functional class of plants in homesteads

Category	Spices		Annuals		Fruit crops		Plantation crops		Timber species		Medicinal plants	
	*Spp	(Density/ha)	*Spp.	(Density/ha)	*Spp.	(Density/ha)	*Spp.	(Density/ha)	*Spp.	(Density/ha)	*Spp.	(Density/ha)
Small HGs	1	600	3	2300	3	436	4	1833	4	1300	-	-
Medium HGs	2	489	2	33	4	356	7	1878	8	1644	1	11
Large HGs	2	1050	1	278	2	133	4	1422	3	1861	1	11
Mean total	3	713	4	870	7	308	7	1711	6	1602	2	11

(*Number of spp.)

The data on diversity indices were shown in the Table 3.4.5. The data indicated that the high mean value of Simpson's diversity index (D) and Shannon- Wiener's diversity index (H') was observed in large HGs. The lowest value of D and H' were in small HGs. The lower values of D show that small HGs flora was shared by many species than others. The higher value of H' indicates that flora of large farms was more stable than others.

Table 3.4. 5. Species diversity and diversity indices in homegardens of high range zone

Class	No. of species	Simpson's index (D)	Shannon-Wiener index (H')
Small HGs	15	0.608	0.569
Medium HGs	24	0.890	1.104
Large HGs	13	0.921	1.266
Total	29		

(Common species in small, medium and large: 7)

3.4. 5.2. Community structure of the HGs

Information on density, basal area, crown area, CLR and mean height was furnished in the Table 3.4.6. (a, b & c). The highest mean density (8450/ha), mean basal area (52.25m^2/ha) and high mean crown area (33,542 m^2/ha) were recorded in large HGs. The lowest value of mean density (6033.33/ha), mean basal area (31.51m^2/ha) and mean crown area (8781.5 m^2/ha) were recorded in small HGs. Generally cocoa (*Theobroma cocoa*), Coffee (C*offea arabica*, *Erythrina indica*, coconut (*Cocos nucifera* L.), pepper (*Piper nigrum*), banana (*Musa* sp.) rubber (*Hevea braziliensis*), mango (*Mangifera indica*), jack (*Artocarpus heterophyllus*), banana (*Musa* sp.), jathi (*Myristica fragrans)* and cashew (*Anacardium occidentale*) were dominant species in all categories of homegardens in terms of density, crown area and basal area. The CLR (%) was more than double of the actual land area (10,000m^2) in medium and large HGs. It implies that canopies of the layers overlapped each other in the homegardens. The total CLR (%) of small HGs, medium HGs and large HGs were followed the order: 87.82, 275.92 and 335.42, respectively (Table 3.4.6. a, b & c).

Table 3.4.6 (a, b & c). Species diversity, certain biometric parameters and community structure of homegardens

a) Small HGs

Sl. NO.	Species	Density (individuals/ /ha)	Mean basal area (m^2/ha)	Mean Crown area (m^2/ha)	Mean CLR (%)	Mean height (m)
1.	*Ailanthus triphysa*	33.33	0.07	58.87	0.59	1
2.	*Amorphophallus companulatus*	3366.67	0.00	0.00	0.00	0.00
3.	*Areca catechu*	466.67	5.06	497.67	4.98	9.53
4.	*Artocarpus heterophyllus*	133.33	5.08	849.67	8.50	9.33
5.	*Capsicum frutescens.*	33.33	0.00	0.00	0.00	0.00
6.	*Coffea arabica*	833.33	1.81	1065.00	10.65	2.48
7.	*Erythrina indica*	600.00	4.71	1727.00	17.27	6.7
8.	*Hevea braziliensis* .	166.67	4.94	424.00	4.24	4.73
9.	*Mangifera indica*	266.67	6.86	1758.33	17.58	9.1

10.	*Morus alba*	33.33	0.33	0.00	0.00	1.5
11.	*Musa sp.*	366.67	1.22	202.80	2.03	2.83
12.	*Piper nigrum*	600.00	0.00	0.00	0.00	0.00
13.	*Psidium guajava*	33.33	0.26	26.17	0.26	0.83
14.	*Theobroma cacao*	166.67	1.18	955.00	9.55	1.61
15.	Unidentified	33.33	0.00	1217.00	12.17	0.00
	Total	6033.33	31.51	8781.50	87.82	

b). Medium HGs

Sl. No.	Species	Density (individuals/ha)	Mean basal area (m^2/ha)	Mean crown area (m^2/ha)	Mean CLR (%)	Mean height (m)
1.	*Ailanthus triphysa*	144.45	0.57	122.00	2.44	5.42
2.	*Anacardium occidentale*	66.67	1.03	443.83	2.22	1.35
3.	*Areca catechu*	422.33	4.23	1130.83	11.31	8.87
4.	*Artocarpus heterophyllus*	100.00	6.97	7596.67	75.97	25.83
5.	*Bombax ceiba*	77.67	1.27	453.56	4.54	7.00
6.	*Capsicum frutescens*	33.33	0.00	0.00	0.00	0.00
7.	*Cocos nucifera*	33.33	0.37	533.33	5.33	1.67
8.	*Coffea arabica*	755.67	5.07	7531.23	75.30	4.50
9.	*Erythrina indica*	866.67	4.53	241.40	2.41	2.41
10.	*Gliricidia sepium*	33.33	0.15	0.00	0.00	1.83
11.	*Grevillea robusta*	133.33	0.66	75.00	0.75	2.79
12.	*Hevea braziliensis*	33.33	0.14	0.00	0.00	0.83
13.	*Garcinia gummi-gutta*	11.10	0.03	78.50	0.79	1.00
14.	*Lannea coromandelica*	11.10	0.28	78.50	0.79	16.67
15.	*Mangifera indica*	166.67	6.20	1953.00	19.53	9.67
16.	*Musa sp.*	133.33	1.97	104.67	1.05	2.33
17.	*Myristica fragrans*	166.67	0.83	1232.08	12.32	3.12
18.	*Piper nigrum*	322.33	0.00	0.00	0.00	0.00
19.	*Prunus sp.*	11.10	0.39	139.56	1.40	2.50
20.	*Psidium guajava*	77.67	0.40	1100.31	11.00	5.00
21.	*Pterocarpus marsupium*	11.10	2.71	314.00	3.14	5.83
22.	*Tectona grandis*	33.33	0.25	33.33	0.33	4.00
23.	*Theobroma cacao*.	433.33	1.47	4460.40	44.60	4.30
24.	Unidentified	22.23	0.05	69.78	0.70	1.08
	Total	4100.08	39.56	27691.98	275.92	

c). Large HGs

Sl NO.	Species	Density (individuals/ha)	Mean Basal area (m^2/ha)	Mean Crown area (m^2/ha)	CLR (%)	Mean Height (m)
1.	*Areca catechu* L.	833.34	9.59	2926.5	29.27	28.6
2.	*Artocarpus heterophyllus* Lamk.	133.33	3.2	1347	13.47	5.57
3.	*Artocarpus hirsutus* Lamk.	266.66	6.41	2694	26.94	11.2
4.	*Cocos nucifera* L.	288.88	17.5	7091.4	70.92	17.9
5.	*Coffea arabica* L.	422.22	1.96	11708	117.1	8.14
6.	*Erythrina indica* Lamk.	3200.04	10.60	1888.72	18.89	5.06
7.	*Gliricidia sepium* (Jack.) Kunth ex Walp.	11.11	0.1	34.89	0.35	1.67
8.	*Haldina cordifolia (*Roxb.*)*	11.11	0.17	139.56	1.4	1.67
9.	*Morus alba* L.	16.67	0.02	13.08	0.13	2.00
10.	*Musa sp.*	277.78	0.72	706.5	7.06	2.75
11.	*Myristica fragrans* Houtt.	166.67	0.55	723.84	7.24	7.10
12.	*Piper nigrum* L.	1933.3	0.00	0.00	0.00	0.00
13.	*Theobroma cacao* L.	1022.2	4.66	5616.1	56.16	6.44
	Total	8450	52.25	33542.02	335.42	

3.4.6. Vertical structure of the HGs

Information on mean density, basal area and crown area of different stratas of vertical structure is provided in table 3.4.7(a, b & c). The data revealed that the highest density and crown area were recorded in S0 and basal area in S2 of small HGs. In case of medium HGs and large HGs, the highest value of density, basal area and crown area were recorded in S1.

Table 3.4.7. Vertical structure of homesteads in high range zone

a) Small HGs

Parameter	Strata				
	S0 (<2m)	S1 (2-7m)	S2 (7-12m)	S3 (12-16)	S4 (>16m)
Mean density (individuals/ ha)	4033.00	1133.00	867.00	-	-
Mean basal area	3.64	10.87	17.00	-	-

(m^2/ha)					
Mean crown area (m^2/ha)	3322	2353.80	3105.40	-	-

b). Medium HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16 m)
Mean density (individuals/ha)	1167.00	2378.00	-	111.00	-
Mean basal area (m^2/ha)	3.68	18.80	-	7.24	-
Mean crown area (m^2/ha)	5218.02	11837.00	-	7675.17	-

c) Large HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16 m)
Mean density (individuals/ha)	1144.00	2761.10	144.00	417.00	-
Mean basal area (m^2/ha)	0.65	13.53	8.73	4.79	-
Mean crown area (m^2/ha)	540.80	12084	3546	1463.00	-

3.4.7. Interventions in the agroforestry systems

A list of 126 species was provided to farmers and after discussion they chose species and suggested the following interventions viz., introduction of annual crops, and introduction of MPTs, introduction of medicinal plants, introduction of fruit crops and introduction of plantation/ cash crops for enhancing the productivity of homegardens. About 83% of small and medium farmers and 69% of large farmers were suggested introduction of multipurpose trees. There were four types of interventions were made in the existing agroforestry systems. A total of 2927 seedlings of 113 species were distributed to the 60 households as interventions (Appendix-2). Of 2927 seedlings, 685 and 802 seedlings of 73 species distributed to small and medium HGs,

respectively where as 1440 seedlings of 65 species were distributed to large HGs (Table 3.4.8).

Table 3.4. 8. Interventions for new agroforestry systems

a) Small HGs

SL. No.	Type of Interventions	No. of species	Quantity (Nos.)	Households (Nos.)
1.	Annuals	06	17	17
2.	Fruit trees	15	110	56
3.	Medicinal plants	26	104	105
4.	Plantation crops	04	91	9
5.	Spices	05	70	27
6.	Trees	17	293	64
	Total	73	685	278

b) Medium HGs

SL. No.	Type of Interventions	No.of species	Quantity (Nos.)	Households (Nos.)
1.	Annuals	06	12	12
2.	Fruit trees	15	75	37
3.	Medicinal plants	24	74	71
4.	Plantation crops	04	106	28
5.	Spices	04	73	27
6.	Trees	20	462	74
	Total	73	802	249

c) Large HGs

SL. No.	Type of Interventions	No.of species	Quantity (Nos.)	Households (Nos.)
1.	Annuals	4	5	5
2.	Fruit trees	14	833	25
3.	Medicinal plants	21	44	30
4.	Plantation crops	3	46	11
5.	Spices	4	39	9
6.	Trees	19	473	59
	Total	65	1440	139

3.5. Onattukara agroclimatic zone

3.5.1. General features

Karunagappally taluk in Kollam district and Karthikapally and Mavelikara Taluks in Alappuzha districts comes under this zone. The blocks covered are Karunagapally and Ochira in Kollam and Muthukulam, Haripad and Mavelikara in Alappuzha district. The zone has a plain level topography. This situation is located in an altitude up to 7.5 m above msl. The situation enjoys a warm humid climate. The annual rainfall varies between 2000 to 3000 mm. About 70% of the rain is received during S-W monsoon period. The mean maximum and minimum temperature in the situation are 30^{o}C and 25^{o}C respectively. A third crop of sesamum is a special feature of the zone. It is raised utilizing residual moisture in the paddy field. The cropping pattern followed are; rice-rice-sesamum in low lands coconut, arecanut, mango, jack, banana cocoa and minor tubers in uplands.

3.5. 2. Size of HGs

Information on size of the land holding class was given in table 3.5.1. Out of 20 randomly selected HGs, small HGs represents 47.06%, medium 29.41% and large HGs 23.53% (Table 3.5.1.). The data revealed that small HGs representation was high. This difference may be due to continuous fragmentation of land and high population pressure. It was observed from the data that the area of HGs was increased with increasing land-holding size of the farmers.

Table 3.5.1. Size of homesteads

Category	Households encountered		Total area (ha)	Mean landholding size (ha)
	Nos.	Percentage		
Small HGs	8	47.06	1.98	0.25
Medium HGs	5	29.41	3.8	0.76
Large HGs	4	23.53	4.93	1.23

3.5. 3. Classes of HGs

The data revealed that small HGs had the 1st and 3rd category of HGs where as medium HGs had first three classes. On the other hand large HGs had category 2 and 3. The 4th class was not encountered in any HGs in this zone (Table 3.5.2.).

Table3. 2. Type of homesteads

Type	Number of households encountered		
	Small	Medium	Large
Homestead alone	7(87.5)	3(60)	-
Homestead cum monoculture	-	1(20)	2(50)
Homestead cum milch animal	1(12.5)	1(20)	2(50)
Homestead cum others	-	-	-

(Parenthesis value show in %)

5.4. Income share of HGs and women's role in HGs management

Regarding income share, highest income share was recorded in large HGs where as small HGs was registered lowest share. In case of role of women in HGs management, small HGs had highest % of women's role and lowest was in large HGs (Table 3.5.3).

Table 3.5.3. Homestead's income share and women's role in homestead management

Category	Number of households encountered					
	Income share			Women's role		
	<25%	25-50%	>50%	<25%	25-50%	>50%
Small HGs	6(75)	1(12.5)	1(12.5)	2(25)	-	6(75)
Medium HGs	-	4(80)	1(20)	1(20)	3(60)	1(20)
Large HGs	-	2(50)	2(50)	3(75)	1(25)	-

(Parenthesis value show in %)

3.5.5. Horizontal structure of HGs

3.5. 5. 1. Species composition and diversity indices

The mean number of species in functional group was given in the Table 3.5.4. Among six functional groups, fruit and timber group were predominant with maximum number of species and density. Out of 51 plant species, there are 12 common species recorded in the zone. A total 5 species in small, 23 in medium and 22 in large HGs were exclusively recorded.

Table 3.5.4. Functional classification of plants in homegardens

Category	Spices		Annuals		Fruit crops		Plantation crops		Timber species		Medicinal plants	
	*Spp	Density (individuals/ha)	* Spp	Density (individuals/ha)	*Spp	Density (Individuals/ha)	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals?ha)	*Spp.	Density (individuals/ha)
Small HGs	1	46	1	120	7	159	3	159	3	324	3	23
Medium HGs	3	543	2	56	12	400	4	1085	9	843	5	100
Large HGs	3	50	1	67	9	275	5	1025	11	1075	7	375
Mean total	5	213	2	81	20	278	5	756	11	728	8	166

(* number of species)

The data on various diversity indices was shown in the Table 3.5.5. Although the previous works have reported that species diversity in the homegardens of Kerala is very high, our analysis indicates that highest Simpson's index (D) and Shannon - Wiener diversity index (H') were recorded in large and small HGs, respectively. The lowest D and H' were recorded in small and medium HGs respectively. The lower values of D show that small HGs flora was shared by many species than others. The higher value of H' indicates that flora of small farms was more stable than others.

Table 3.5.5. Species composition and diversity indices

Category	No. Of species	Simpson's diversity index (D)	Shannon- wiener's index (H')
Small HGs	17	0.915	1.393
Medium HGs	35	0.919	1.292
Large HGs	34	0.921	1.299
Total	51	-	-

(Common species in small medium and large HGs: 12)

3.5.5.2. Community structure of the HGs

Information on mean density, basal area, crown area, CLR and mean height is given in table 3.5.6. (a, b & c). The high mean density (3425/ha) and mean basal area (49.63m^2/ha) and crown area (37313.95 m^2/ha) were registered in large HGs. The

lowest of mean density (750/ha), mean basal area (18.71m^2/ha) and crown area (11965.*1* m^2/ha) in small HGs respectively. At a glance, the general spatial arrangement shows that most of large homegardens were over crowded while none of the gardens in the small HGs were over crowed. The CLR (%) data revealed that the maximum CLR (373.13%) was recorded in large HGs followed by medium (211.06%) and small (18.31%). The large HGs showed high value in terms of CLR. This difference may be due to wider crown development because of more space availability. In terms of density, basal area and crown area, coconut, arecanut, pepper, banana, guava, mahogany, mango and jack are dominant species in this zone.

Table 3.5.6. Species diversity, certain biometric parameters and community structure of homegardens

a). Small HGs

Sl. NO.	Species	Density /ha	Basal area (m^2/ha)	Crown area (m^2/ha)	CLR (%)	Height (m)
1.	*Ailanthus triphysa*	22.7	0.3042	285.455	2.85455	9.5
2.	*Anacardium occidentale*	22.7	1.2167	446.023	4.46023	7.5
3.	*Areca catechu*	90.9	1.1581	71.3636	0.71364	12.5
4.	*Artocarpus heterophyllus*	45.5	0.9047	892.045	8.92045	10
5.	*Carica papaya*	22.7	0.0261	71.3636	0.71364	3
6.	*Cocos nucifera*	136	6.3123	5245.23	52.4523	23.5
7.	*Garcinia gummi-gutta*	45.5	0.3706	321.136	3.21136	0.8
8.	*Gliricidia sepium*	159	1.5076	44.9591	0.44959	4
9.	*Flacourtia jangomas*	22.7	0.0586	17.8409	0.17841	0.4
10.	*Mangifera indica*	45.5	1.6734	1507.56	15.0756	12.5
11.	*Michelia champaca*	22.7	0.1319	285.455	2.85455	8
12.	*Moringa oleifera*	22.7	0.0147	17.8409	0.17841	2.5
13.	*Musa sp.*	68.40	0.3810	160.57	1.6059	3.5
14.	*Piper nigrum*	152.5	0	20.6098	0.2061	
15.	*Psidium guajava*	45.5	0.0058	1748.41	17.4841	7
16.	*Swietenia mahagoni*	68.2	6.0994	856.364	8.56364	17
17.	*Vitex altissima*	22.7	0.0407	17.8409	0.17841	4
	Total	750	18.708	11965.1	119.651	

b). Medium HGs

Sl. No.	Species	Density (individuals/ha)	Basal area (m^2/ha)	Crown area (m^2/ha)	CLR (%)	Mean Height (m)
1.	*Acacia mangium*	42.90	1.1344	302.786	3.02786	12.00
2.	*Achras sapota*	28.60	0.4013	560.714	5.60714	6.50
3.	*Anacardium occidentale*	57.10	1.7489	908.357	9.08357	8.75
4.	*Annona squamosa*	28.60	0.0657	89.7143	0.89714	4.00
5.	*Areca catechu*	500.00	1.8834	1304.00	13.04	3.3
6.	*Artocarpus communis*	28.60	0.1783	140.179	1.40179	13.50
7.	*Artocarpus heterophyllus*	71.40	2.5835	1291.89	12.9189	23.80
8.	*Artocarpus hirsutus*	57.10	5.8774	837.142	8.37142	11.12
9.	*Averrhoa bilimbi*	42.90	0.0000	0.45	0.0045	0.50
10.	*Azadirachta indica*	28.60	0.0446	201.857	2.01857	6.00
11.	*Bambusa vulgaris*	14.30	0.0655	280.357	2.80357	15.50
12.	*Carica papaya*	57.10	0.1700	0.5	0.005	4.00
13.	*Cocos nucifera*	400.00	20.1080	6702.14	67.0214	11.07
14.	*Garcinia gummi-gutta*	71.40	1.0613	379.043	3.79043	11.00
15.	*Hibiscus rosa-sinensis*	14.30	0.0892	11.2143	0.11214	1.50
16.	*Jatropha curcus*	14.3	0.0369	11.2143	0.11214	2.00
17.	*Lannea coromandelica*	14.30	0.1820	44.8571	0.44857	10.00
18.	*Citrus sp.*	14.30	0.0369	44.8571	0.44857	2.50
19.	*Flacourtia jangomas*	14.30	0.0369	44.8571	0.44857	3.50
20.	*Macaranga peltata*	28.60	0.2630	201.857	2.01857	6.25
21.	*Mangifera indica*	243.00	5.7854	4104.46	41.0446	8.20
22.	*Manihot utilissima*	0.00	0.0000	0	0.00000	1.00
23.	*Ailanthus triphysa*	28.60	0.0000	0.3	0.003	1.00
24.	*Michelia champaca*	14.30	0.0829	717.714	7.17714	13.50
25.	*Moringa oleifera*	71.40	0.0932	322.971	3.22971	5.70
26.	*Musa paradisiacal*	214.00	1.0266	859.171	8.59171	3.43
27.	*Myristica fragrans*	28.60	0.0657	201.857	2.01857	6.00
28.	*Piper nigrum*	543.00	0.0000	153.411	1.53411	2.50
29.	*Psidium guajava*	28.60	0.0582	678.464	6.78464	6.00
30.	*Gliricidia sepium*	42.90	0.1025	14.6548	0.14655	2.33
31.	*Swietenia mahagoni*	85.70	1.4023	269.143	2.69143	10.83
32.	*Syzygium aromaticum*	57.10	0.1093	179.429	1.79429	4.25
33.	*Tectona grandis*	129.00	2.7414	714.13	7.1413	9.94
34.	*Thespesia populnea*	114.00	1.7712	137.945	1.37945	8.12

35.	*Vitex altissima*	14.30	0.0000	0.25	0.0025	0.50
	Total	3057.00	48.4500	21106.3	211.06	

c) Large HGs

Sl NO.	Species	Density (individuals/ha	Basal area (m^2/ha)	Crown area (m^2/ha)	CLR (%)	Mean height (m)
1.	*Acacia mangium*	25.00	0.65	314.00	3.14	16.00
2.	*Ailanthus triphysa*	125.00	0.85	251.20	2.51	8.20
3.	*Anacardium occidentale* .	25.00	0.11	19.63	0.20	6.50
4.	*Areca catechu*	425.00	3.68	333.63	3.34	14.47
5.	*Artocarpus heterophyllus*	100.00	1.97	17662.50	176.63	11.00
6.	*Artocarpus hirsutus*	100.00	2.84	1411.24	14.11	13.75
7.	*Azadirachta indica*	50.00	0.09	157.00	1.57	4.00
8.	*Artocarpus communis*	25.00	0.12	78.50	0.79	8.00
9.	*Carica papaya*	25.00	0.15	78.50	0.79	3.00
10.	*Cassia fistula*	25.00	0.44	490.63	4.91	9.0
11.	*Michelia champaca*	25.00	0.02	19.63	0.20	8.00
12.	*Cinnamomum malabaricum*	25.00	0.03	78.50	0.79	4.00
13.	*Citrus sp.*	25.00	0.04	176.63	1.77	10.00
14.	*Cocos nucifera*	200.00	10.22	3351.07	33.51	19.37
15.	*Coffea arabica*	50.00	0.08	9.81	0.10	2.00
16.	*Croton* spp	625.00	0.72	176.63	1.77	1.00
17.	*Garcinia gummi-gutta*	75.00	0.81	529.88	5.30	7.5
18.	*Lagerstroemia reginae*	50.00	1.08	628.00	6.28	11.00
19.	*Macaranga peltata*	50.00	0.04	157.00	1.57	3.50
20.	*Mangifera indica*	300..00	6.41	2087.76	20.88	9.5
21.	*Hydnocarpus pentandra*	50.00	1.08	1413.00	14.13	9.75
22.	*Moringa oleifera*	50.00	0.10	39.25	0.39	4.25
23.	*Musa sp*	300.00	0.26	2119.50	21.20	2.87
24.	*Myristica fragrans*	25.00	0.08	314.00	3.14	7.00
25.	*Caryota urens*	25.00	3.63	490.63	4.91	18.00
26.	*Citharexylum sp.*	250.00	0.20	49.06	0.49	0.50
27.	*Piper nigrum*	305.00	-	-	-	-
28.	*Polyalthia longifolia* .	25.00	0.07	1962.50	19.63	10.00
29.	*Psidium guajava*	50.00	0.36	794.81	7.95	5.75
30.	*Leucaena leucocephala*	50.00	0.19	39.25	0.39	4.50
31.	*Swietenia mahagoni*	75.00	2.22	529.88	5.30	12.16
32.	*Tectona grandis*	50.00	8.84	981.25	9.81	21.50

33.	*Thespesia populnea*	75.00	2.19	78.51	0.79	12.66
34.	*Dalbergia latifolia*	*25.00*	*0.07*	*490.63*	*4.91*	*10.00*
	Total	*3425.00*	*49.63*	*37313.95*	*373.13*	

3.5. 6. Vertical structure of the HGs

Based on plants height, multi-layered canopy structure of homegardens was vertically stratified in to five stratas viz., S0 (<2m), S1 (2-7m), S2(7-12m), S3(12-16m) and S4 (>16m). The maximum mean basal area and crown area were recorded in S4 of small HGs while maximum mean density was in S1 of the same. The highest mean density, basal area, and crown area were recorded in S2 of medium HGs where as in large HGs high mean density, basal area and crown area were recorded in S0, S4 and S1 respectively.

Table 3.5.7. Vertical structure of homesteads

a) Small HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16 m)
Density (individuals/ha)	114	341.00	159.00	91.00	205.00
Basal area (m^2/ha)	0.4292	1.986	4.231	1.158	12.41
Crown area (m^2/ha)	359.59	2060.982	3416.534	71.364	6101.591

b) Medium HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16 m)
Density (individuals/ha)	986	643	1300	57.6	71.4
Basal area (m^2/ha)	0.5027	2.474	42.56	0.3267	2.583
Crown area (m^2/ha)	269.69	3400.90	15006	1138.20	1291.9

c)Large HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16m)
Density (ha^{-1})	925	725	825	625	325
Basal area (m^2/ha)	0.9936	1.8647	14.083	9.3959	23.293
Crown area (m^2/ha)	235.50	5956.20	23320	2588.71	5176.19

3.6. Kole agroclimatic zone

3. 6.1. General features

This zone is located in Thrissur, Chavakkad and Mukundapuram taluks in Trichur district and Ponnani taluk of Malappuram district extending over an area of 15423 ha. Of the total area of the zone, Trichur district covers a total area of 11798 ha and Malappuram district covers a total area of 3625 ha. The lands of the zone lie below sea level. The climate of the zone is moderate. The annual rainfall varies between 2000-4000 mm. The minimum temperature goes down to 21^{o}C and maximum temperature goes upto 38^{o}C. About 70% of rainfall received is from S-W monsoon. Kole land form a part of Karuvannur river basin moderately heavy rainfall during monsoon seasons. The soil of Kole lands is acidic and toxic salts of Fe and Al produced in the soil which hamper agricultural production. The Kole lands are frequently confronted with floods during monsoon season, ingression of saline water during summer months and production of acidity and toxicity during the cropping season.

3. 6. 2. Size of HGs

Out of 41 randomly selected HGs, small HGs represents 58.5%, medium 29.3% and large HGs 12.2% (Table 3.6.1.). The common trend of increasing the percentage share of HGs to the total cultivated area with increasing total land-holding size was observed in this zone.

Table 3.6.1. Size of homesteads

Category	Households encountered		Total land holding size (ha)	Mean landholding size (ha)
	Nos.	Percentage (%)		
Small HGs	24	58.5%	4.51	0.19
Medium HGs	12	29.3%	5.53	0.46
Large HGs	05	12.2%	6.80	1.36

3. 6. 3. Classes of HGs

The data revealed that both small and medium HGs had class1 (homestead alone) and class 3 (homestead with milch animal) where as large HGs had all four classes of HGs. The main reason for this difference is dependency on HGs varies on category to another (Table 3.6.2.).

Table 3. 6.2. Type of homesteads

Type	Number of households encountered		
	Small HGs	Medium HGs	Large HGs
Homestead alone	21(88%)	-	01(20%)
Homestead cum monoculture	-	01(8%)	02(40%)
Homestead cum milch animal	03(12%)	11(92%)	01(20%)
Homestead cum others (fishery/ Apiculture)	-	-	01(20%)

3.6. 4. Income share of homestead and women's role in homestead management

Like other zones, about 75% of the small HGs comes under class 1 (income less than 25% from HGs), while 42% medium HGs and 80% large HGs comes under class2 (income 25-50 %) and class 3 (income more than 50 %). Based on the degree of women's role in management of HGs, HGs were grouped into three classes viz., Class 1 (less than 25% involvement), class 2 (25-50 % involvement) and class 3 (more than 50 % involvement). The data showed that class 1 was predominant in large HGs class 2 in medium HGs and class 3 in small HGs (Table 3.6.3.).

Table 3.6.3. Homestead's income share and women's role in homestead management

Category	Number of households encountered					
	Income share			Women's role		
	<25%	25-50%	>50%	<25%	25-50%	>50%
Small HGs	18(75)	04(17)	02(8)	-	07(29)	17(71)
Medium HGs	02(16)	05(42)	05(42)	08(33)	08(67)	04(33)
Large HGs	-	01(20)	04(80)	05(100)	-	-

(Values in parenthesis show in percentage)

3. 6. 5. Horizontal structure of HGs

3.6.5.1. Species composition and diversity indices

The horizontal structure deals with spatial arrangements of plants in the HGs. The concerned farmers decide the spatial distribution of plants. The total encountered plant species were grouped in to six functional groups viz., annuals, fruit, plantation, timber, spices and medicinal plants. Of the total 60 species recorded include 2 annuals, 8 fruit, 6 plantation, 13 timber, 4 spices and 9 medicinal plants (Table 3.6.4). It is concluded that most of the small farmers preferred fruit crops, medium farmers both fruit and timber species equally and large farmers preferred more timber species than other crops.

Table 3.6.4. Functional class of plants in homesteads

Category	Spices		Annuals		Fruit crops		Plantation crops		Timber species		Medicinal plants	
	*Spp	Density (individuals/ha)	*Spp.	Density (individuals/ha	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals|ha)
Small HGs	2	11	1	3	11	34	4	518	5	39	3	6
Medium HGs	3	213	1	142	13	202	6	3200	5	550	3	10
Large HGs	2	443	2	169	12	136	7	1100	12	600	9	11
Mean total	4	222	2	105	17	124	7	1739	18	396	12	9

(* Actual species number)

The data revealed that 15 common species were recorded in the HGs of the zone. A total of 14, 19 and 32 species were exclusively recorded in small HGs, medium HGs and large HGs, respectively. The data on diversity indices was shown that mean Simpson's Index (D) and Shannon- Wiener diversity index (H') were high in medium HGs and large HGs, respectively. The low value of D and H' were recorded in small and medium HGs, respectively. The lower values of D show that small HGs flora was

shared by many species than others. The higher value of H' indicates that flora of large farms was more stable than others (Table 3.6.5).

Table 3.6. 5. Species diversity and diversity indices in homegardens

Class	No. of species	Simpson's Index (D)	Shannon- Wiener index (H')
Small HGs	26	0.600	1.09
Medium HGs	31	0.872	1.06
Large HGs	44	0.80	1.28
Total	60	-	-

(Common species to all HGs-15)

3.6.5.2. Community structure of HGs

Data on density, basal area, crown area, CLR and mean height were furnished in the Table 6.6. (a, b & c). The high mean basal area (31.66 m^2/ha), and Mean crown area (21331.21 m^2/ha) were recorded in large HGs where as the mean density per hectare was maximum in medium HGs. The lowest value of mean basal area (7.22 m^2/ha) and crown area (16536.64 m^2/ha) was recorded in small HGs and medium HGs, respectively. Coconut (*Cocos nucifera* L.), arecanut (*Areca catechu*), jathi (*Myristica fragrans*) , banana(*Musa* sp.), Matti (*Ailanthus triphysa*), Ayini (*Artocarpus hirsutus*, teak(*Tectona grandis*), mango (*Mangifera indica*), jack (*Artocarpus heterophyllus*) and bread fruit (*Artocarpus communis*) were dominant species in all categories of HGs in terms of density, crown area and basal area. CLR (%) has been worked out for three different form holdings size classes such small, medium and large. The CLR (%) was more than 200% in small and large homegardens, where as in medium HGs it was only 165%. It means that canopies of the species overlapped each other in the homegardens (Table 3.6.6.a, b & c). It helps to find gap for improvement in the productivity in the homegardens. This difference may due to that the small farmers were tried to increase maximum yield from the limited land area where as large farmers were put maximum managerial inputs to get maximum possible benefits.

In general, species density and diversity are high in the nucleus (home) of the homesteads and decreases from nucleus to the boundary of homegardens. This may be due to the fact that farmer can give more care and attention to nearest surroundings of the homegardens. It was observed that the intensity of management and cultivation of annuals, fruit crops and other vegetables were confined to surroundings of nucleus of homegardens also.

Table 3.6.6. Species diversity, certain biometric parameters and community structure of homegardens

a) Small HGs

Sl. No.	Species	Density (individuals/ha)	Mean basal area (m^2/ha)	Mean crown area (m^2/ha)	Mean CLR (%)
1.	*Anacardium occidentale*	4.50	0.07	145.33	1.54
2.	*Areca catechu*	1.33	0.02	39.92	0.40
3.	*Artocarpus communis*	8.33	0.65	50.25	0.50
4.	*Artocarpus heterophyllus*	10.33	0.02	114.76	1.15
5.	*Averrhoa bilimbi*	1.33	0.01	0.77	0.01
6.	*Cananga odorata*.	1.33	0.01	0.77	0.01
7.	*Carissa caronda*	1.33	0.00	0.26	0.00
8.	*Cinnamomum malabatrum*	1.33	0.03	2.06	0.02
9.	*Citrus sp.*	1.33	0.00	0.00	0.00
10.	*Cocos nucifera*	1.33	0.02	1.55	0.02
11.	*Embilica officinalis*	2.67	0.01	0.77	0.01
12.	*Eugenia jambos*	4.00	0.03	2.06	0.02
13.	*Fahrenheitia integrifolia*	4.33	0.09	143.27	1.43
14.	*Garcinia gummi-gutta*	1.33	0.02	35.23	0.35
15.	*Embilica officinalis*	12.67	0.05	3.87	0.04
16.	*Lannea coromandelica*	1.33	0.01	1.03	0.01
17.	*Malus pumila*	234.67	0.62	2116.39	21.16
18.	*Mangifera indica*	356.00	0.31	1248.33	12.48
19.	*Michelia champaca*	1.33	0.00	0.00	
20.	*Moringa oleifera*	1.33	0.00	0.00	0.00
21.	*Musa sp..*	2.67	0.00	0.00	0.00
22.	*Psidium guajava*	14.00	0.46	745.94	7.46
23.	*Tamarindus indica*	5.33	0.15	22.81	0.23
24.	*Tectona grandis*	1.33	0.00	0.00	0.00
25.	*Unidentified*	102.67	4.62	15613.45	156.13
26.	*Vitex altissima.*	2.67	0.00	0.00	0.00
	Total	**782.17**	**7.22**	**20290.89**	**203.00**

b) Medium HGs

Sl. No.	Species	Density (individuals/ha)	Mean basal area/ha (m^2/ha)	Mean crown area/ha (m^2/ha)	CLR (%)	Mean height (m)
1.	*Anacardium occidentale*	33.33	0.44	339.12	1.13	21.00
2.	*Annona squamosa*	5.67	0.00	0.00	0.00	0.00
3.	*Areca catechu*	1027.67	7.61	7260.47	72.60	6.00
4.	*Artocarpus communis*	8.33	0.07	62.06	0.62	9.00
5.	*Artocarpus heterophyllus*	12.67	0.03	0.00	0.00	0.00
6.	*Averrhoa bilimbi*	16.67	0.67	301.44	3.01	18.00
7.	*Calophyllum inophyllum*	2.67	0.03	52.33	0.52	4.50
8.	*Carica papaya*	16.67	0.04	52.33	0.52	8.00
9.	*Caryota urens*	5.67	0.10	160.14	1.60	0.00
10.	*Cinnamomum malabatrum*	11.33	0.25	320.28	3.20	0.00
11.	*Citrus sp.*	8.33	0.02	163.54	1.64	5.00
12.	*Cocos nucifera*	214.00	0.25	0.00	0.00	0.00
13.	*Coffea arabica*	2.67	0.01	0.00	0.00	2.50
14.	*Erythrina indica*	5.33	0.02	0.00	0.00	0.00
15.	*Fahrenheitia integrifolia*	8.33	0.12	138.42	1.38	4.00
16.	*Ficus glomerata*	5.67	0.06	40.04	0.40	9.00
17.	*Garcinia gummi-gutta*	16.67	0.09	29.44	0.29	6.54
18.	*Gliricidia sepium*	8.33	0.03	40.89	0.41	12.00
19.	*Ixora coccinia*	16.67	0.07	209.33	2.09	4.50
20.	*Lagerstroemia reginae*	2.67	0.04	85.74	0.86	8.00
21.	*Mangifera indica*	16.67	0.02	0.00	0.00	3.50
22.	*Murraya koenigi*	8.33	1.59	1139.82	11.40	9.00
23.	*Musa sp.*	141.67	1.56	1285.57	12.86	16.50
24.	*Myristica fragrans*.	25.00	1.44	829.16	8.29	12.00
25.	*Piper nigrum*	17.33	0.00	0.00	0.00	4.50
26.	*Spondias pinnata*	5.67	0.18	0.00	0.00	12.50
27.	*Syzygium cumini*	8.33	0.00	0.00	0.00	2.00
28.	*Tamarindus indica*	8.33	0.10	0.00	0.00	1.00
29.	*Tectona grandis*	58.33	2.56	3875.81	38.76	12.00
30.	*Terminalia catappa*	8.33	0.04	150.72	1.51	5.00
31.	*Theobroma cacao*	25.00	0.09	0.00	0.00	3.50
	Total	1752.33	17.52	16536.64	165.37	-

c) Large HGs

Sl. No.	Species	Density (individuals /ha)	Mean basal area (m^2/ha)	Crown area (m^2/ha)	CLR (%)	Height (m)
1.	*Adenanthera pavonina*	3.33	0.08	0.00	0.00	13.00
2.	*Ailanthus triphysa*	67.00	1.64	0.00	0.00	15.00
3.	Alston*ia scholaris*	5.67	0.03	139.50	1.39	4.50
4.	*Anacardium occidentale*	5.00	0.12	19.69	0.20	
5.	*Ananas comosus*	166.67	0.00	0.00	0.00	
6.	*Annona squamosa*	5.67	0.05	0.00	0.00	6.00
7.	*Areca catechu*	585.67	8.03	3604.43	36.04	15.50
8.	*Artocarpus communis*	4.67	0.47	443.26	4.43	13.00
9.	*Artocarpus heterophyllus*	14.67	0.49	1245.28	12.45	13.00
10.	*Artocarpus hirsutus*	10.67	3.00	380.38	3.80	15.00
11.	*Averrhoa bilimbi*	4.67	0.10	131.88	1.32	6.00
12.	*Bombax ceiba*	4.67	0.03	0.00	0.00	5.00
13.	*Caesalpinia coriaria.*	4.67	0.01	0.00	0.00	4.50
14.	*Cananga odorata*	1.67	0.08	31.41	0.31	19.50
15.	*Carica papaya*	3.00	0.00	0.00	0.00	
16.	*Caryota urens*	2.00	0.15	0.00	0.00	16.00
17.	*Citrus sp.*	14.33	0.00	0.00	0.00	1.50
18.	*Cocos nucifera*.	168.67	6.96	9342.38	93.42	18.50
19.	*Coffea arabica*	1.67	0.01	11.78	0.12	3.50
20.	*Erythrina indica*	9.67	0.00	0.00	0.00	1.50
21.	*Eugenia jambos*	9.00	0.08	25.50	0.26	6.00
22.	*Ficus glomerata*	2.67	0.05	0.00	0.00	5.00
23.	*Garcinia gummi-gutta*	5.00	0.12	192.33	1.92	5.50
24.	*Gliricidia sepium*	14.33	0.05	0.00	0.00	6.00
25.	*Gmelina arborea*	3.00	0.57	0.00	0.00	15.00
26.	*Hevea braziliensis*	1.67	0.16	0.00	0.00	19.00
27.	*Hibiscus rosa-sinensis*	14.33	0.00	0.00	0.00	3.50
28.	*Hydnocarpus pentandra*	5.00	1.22	0.00	0.00	18.00
29.	*Jatropha spp.*	14.33	0.03	0.00	0.00	4.50
30.	*Lannea coromandelica.*	7.33	0.06	64.99	0.65	5.00
31.	*Macaranga peltata*	5.67	0.10	71.17	0.71	7.00
32.	*Mangifera indica*.	19.00	3.97	816.75	8.17	17.00
33.	*Musa sp.*	170.67	2.88	4052.69	40.53	3.00
34.	*Myristica fragrans*	14.33	0.12	157.38	1.57	5.50
35.	*Ocimum sanctum*	47.67	0.00	0.00	0.00	1.00
36.	*Piper nigrum*	14.33	0.00	0.00	0.00	
37.	*Plumaria alba*	3.00	0.04	71.24	0.71	5.60

38.	*Psidium guajava*	1.67	0.02	0.00	0.00	4.00
39.	*Syzygium cumini*	4.67	0.10	38.46	0.38	9.00
40.	*Tamarindus indica*	3.00	0.22	74.38	0.74	4.00
41.	*Tectona grandis*	6.33	0.11	0.80	0.01	8.50
42.	*Terminalia catappa*	9.67	0.17	273.18	2.73	8.50
43.	*Theobroma cacao*	11.33	0.15	142.35	1.42	6.50
44.	*Trema orientalis*	1.33	0.18	0.00	0.00	11.50
	Total	1473.33	31.66	21331.21	213.31	-

3. 6. 6.Vertical structure of the HGs

Like other zones vertical structure of HGs was stratified in to 5 stratas viz. S0 (<2m), S1 (2-7m), S2 (7-12m), S3 (12-16m) and S4 (>16m). The maximum mean density per hectare, basal area and crown area were recorded in S1 of small HGs while S4 strata of medium and large HGs had maximum mean density per hectare, basal area and crown area. S1 of small HGs, S4 of medium HGs and large HGs were predominant in terms of mean density per hectare, basal area and crown area (Table 3.6.7. a, b and c).

Table 3.6.7. Vertical structure of homesteads

a) Small HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16 m)
Density (individuals/ha)	65	1474	378	892	16
Mean basal area (m^2/ha)	0.2	25.72	5.97	16.80	01.22
Mean crown area (m^2/ha)	70.20	34938.38	6643.89	18088.07	319.79

b) Medium HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16 m)
Density (individuals/ha)	125	600	550	250	3100
Mean basal area (m^2/ha)	-	04.62	4.96	2.64	80.20
Mean crown area	-	7717.5	5691.6	4069.80	30780

(m^2/ha)					

b) Large HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16 m)
Density (individuals/ha)	129	614	100	314	1086
Mean basal area (m^2/ha)	03	0.31	0.10	0.55	38.02
Mean crown area (m^2/ha)	4.38	84.02	30.50	13.72	49990.16

3.6.7. Interventions in the agroforestry systems

A list of 126 species was distributed to the farmers of the Kole zone. Farmers were suggested 4 type of interventions viz., introduction of annual crops, introduction of MPTs, introduction of medicinal plants, introduction of fruit crops and introduction of plantation/ cash crops for enhancing the productivity of homegardens. Four types of interventions were made in the existing agroforestry systems, a total of 997 seedlings belonging to 76 species were distributed to the 59 households as interventions (Appendix-2). Out of 997, 554 plants of 60 species, 335 plants of 45 species and 108 plants of 29 species were distributed to small HGs, Medium HGs and large HGs, respectively. Of 997 plants, 8% are fruit trees, 7% medicinal plants and plantation crops, 28% spices and 40% trees were included (Table 3.6.8). Monitoring survey showed that about 92 % of 997 plants have survived.

Table 3.6.8. Interventions for new agroforestry models

a) Small HGs

SL. No.	Type of Interventions	No. of species	Quantity (Nos.)	Households (Nos.)
1	Annuals	-	-	-
2	Fruit trees	15	98(18)	50
3	Medicinal plants	15	37(7)	16
4	Plantation crops	4	41(7)	7

5	Spices	5	158(28)	21
6	Trees	21	220(40)	54
	Total	60	554	148

b) Medium HGs

SL. No.	Type of Interventions	No. of species	Quantity (Nos.)	Households (Nos.)
1	Annuals	2	6(2)	2
2	Fruit trees	10	40(12)	20
3	Medicinal plants	11	43(13)	17
4	Plantation crops	3	25(7)	7
5	Spice	4	150(45)	11
6	Trees	15	71(21)	21
	Total	45	335	78

c) Large HGs

SL. No.	Type of Interventions	No. of species	Quantity (Nos.)	Households (Nos.)
1	Annuals	-	-	-
2	Fruit trees	7	7(6)	8
3	Medicinal plants	5	10(9)	5
4	Plantation crops	2	24(22)	2
5	Spice	1	2(2)	1
6	Trees	14	65(61)	16
	Total	29	108	31

(Values in parenthesis show percentage**)**

3.6. Kole agroclimatic zone

3. 6.1. General features

This zone is located in Thrissur, Chavakkad and Mukundapuram taluks in Trichur district and Ponnani taluk of Malappuram district extending over an area of 15423 ha. Of the total area of the zone, Trichur district covers a total area of 11798 ha and Malappuram district covers a total area of 3625 ha. The lands of the zone lie below sea level. The climate of the zone is moderate. The annual rainfall varies between 2000-4000 mm. The minimum temperature goes down to 21^{o}C and maximum temperature goes upto 38^{o}C. About 70% of rainfall received is from S-W monsoon. Kole land form a part of Karuvannur river basin moderately heavy rainfall during monsoon seasons. The soil of Kole lands is acidic and toxic salts of Fe and Al produced in the soil which hamper agricultural production. The Kole lands are frequently confronted with floods during monsoon season, ingression of saline water during summer months and production of acidity and toxicity during the cropping season.

3. 6. 2. Size of HGs

Out of 41 randomly selected HGs, small HGs represents 58.5%, medium 29.3% and large HGs 12.2% (Table 3.6.1.). The common trend of increasing the percentage share of HGs to the total cultivated area with increasing total land-holding size was observed in this zone.

Table 3.6.1. Size of homesteads

Category	Households encountered		Total land holding size (ha)	Mean landholding size (ha)
	Nos.	Percentage (%)		
Small HGs	24	58.5%	4.51	0.19
Medium HGs	12	29.3%	5.53	0.46
Large HGs	05	12.2%	6.80	1.36

3. 6. 3. Classes of HGs

The data revealed that both small and medium HGs had class1 (homestead alone) and class 3 (homestead with milch animal) where as large HGs had all four classes of HGs. The main reason for this difference is dependency on HGs varies on category to another (Table 3.6.2.).

Table 3. 6.2. Type of homesteads

Type	Number of households encountered		
	Small HGs	Medium HGs	Large HGs
Homestead alone	21(88%)	-	01(20%)
Homestead cum monoculture	-	01(8%)	02(40%)
Homestead cum milch animal	03(12%)	11(92%)	01(20%)
Homestead cum others (fishery/ Apiculture)	-	-	01(20%)

3.6. 4. Income share of homestead and women's role in homestead management

Like other zones, about 75% of the small HGs comes under class 1 (income less than 25% from HGs), while 42% medium HGs and 80% large HGs comes under class2 (income 25-50 %) and class 3 (income more than 50 %). Based on the degree of women's role in management of HGs, HGs were grouped into three classes viz., Class 1 (less than 25% involvement), class 2 (25-50 % involvement) and class 3 (more than 50 % involvement). The data showed that class 1 was predominant in large HGs class 2 in medium HGs and class 3 in small HGs (Table 3.6.3.).

Table 3.6.3. Homestead's income share and women's role in homestead management

Category	Number of households encountered					
	Income share			Women's role		
	<25%	25-50%	>50%	<25%	25-50%	>50%
Small HGs	18(75)	04(17)	02(8)	-	07(29)	17(71)
Medium HGs	02(16)	05(42)	05(42)	08(33)	08(67)	04(33)
Large HGs	-	01(20)	04(80)	05(100)	-	-

(Values in parenthesis show in percentage)

3. 6. 5. Horizontal structure of HGs

3.6.5.1. Species composition and diversity indices

The horizontal structure deals with spatial arrangements of plants in the HGs. The concerned farmers decide the spatial distribution of plants. The total encountered plant species were grouped in to six functional groups viz., annuals, fruit, plantation, timber, spices and medicinal plants. Of the total 60 species recorded include 2 annuals, 8 fruit, 6 plantation, 13 timber, 4 spices and 9 medicinal plants (Table 3.6.4). It is concluded that most of the small farmers preferred fruit crops, medium farmers both fruit and timber species equally and large farmers preferred more timber species than other crops.

Table 3.6.4. Functional class of plants in homesteads

Category	Spices		Annuals		Fruit crops		Plantation crops		Timber species		Medicinal plants	
	*Spp	Density (individuals/ha)	*Spp.	Density (individuals/ha	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals/ha)	*Spp.	Density (individuals|ha)
Small HGs	2	11	1	3	11	34	4	518	5	39	3	6
Medium HGs	3	213	1	142	13	202	6	3200	5	550	3	10
Large HGs	2	443	2	169	12	136	7	1100	12	600	9	11
Mean total	4	222	2	105	17	124	7	1739	18	396	12	9

(* Actual species number)

The data revealed that 15 common species were recorded in the HGs of the zone. A total of 14, 19 and 32 species were exclusively recorded in small HGs, medium HGs and large HGs, respectively. The data on diversity indices was shown that mean Simpson's Index (D) and Shannon- Wiener diversity index (H') were high in medium HGs and large HGs, respectively. The low value of D and H' were recorded in small and medium HGs, respectively. The lower values of D show that small HGs flora was

shared by many species than others. The higher value of H' indicates that flora of large farms was more stable than others (Table 3.6.5).

Table 3.6. 5. Species diversity and diversity indices in homegardens

Class	No. of species	Simpson's Index (D)	Shannon- Wiener index (H')
Small HGs	26	0.600	1.09
Medium HGs	31	0.872	1.06
Large HGs	44	0.80	1.28
Total	60	-	-

(Common species to all HGs-15)

3.6.5.2. Community structure of HGs

Data on density, basal area, crown area, CLR and mean height were furnished in the Table 6.6. (a, b & c). The high mean basal area (31.66 m^2/ha), and Mean crown area (21331.21 m^2/ha) were recorded in large HGs where as the mean density per hectare was maximum in medium HGs. The lowest value of mean basal area (7.22 m^2/ha) and crown area (16536.64 m^2/ha) was recorded in small HGs and medium HGs, respectively. Coconut (*Cocos nucifera* L.), arecanut (*Areca catechu*), jathi (*Myristica fragrans*) , banana(*Musa* sp.), Matti (*Ailanthus triphysa*), Ayini (*Artocarpus hirsutus*, teak(*Tectona grandis*), mango (*Mangifera indica*), jack (*Artocarpus heterophyllus*) and bread fruit (*Artocarpus communis*) were dominant species in all categories of HGs in terms of density, crown area and basal area. CLR (%) has been worked out for three different form holdings size classes such small, medium and large. The CLR (%) was more than 200% in small and large homegardens, where as in medium HGs it was only 165%. It means that canopies of the species overlapped each other in the homegardens (Table 3.6.6.a, b & c). It helps to find gap for improvement in the productivity in the homegardens. This difference may due to that the small farmers were tried to increase maximum yield from the limited land area where as large farmers were put maximum managerial inputs to get maximum possible benefits.

In general, species density and diversity are high in the nucleus (home) of the homesteads and decreases from nucleus to the boundary of homegardens. This may be due to the fact that farmer can give more care and attention to nearest surroundings of the homegardens. It was observed that the intensity of management and cultivation of annuals, fruit crops and other vegetables were confined to surroundings of nucleus of homegardens also.

Table 3.6.6. Species diversity, certain biometric parameters and community structure of homegardens

a) Small HGs

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2.	*Areca catechu*	1.33	0.02	39.92	0.40
3.	*Artocarpus communis*	8.33	0.65	50.25	0.50
4.	*Artocarpus heterophyllus*	10.33	0.02	114.76	1.15
5.	*Averrhoa bilimbi*	1.33	0.01	0.77	0.01
6.	*Cananga odorata*.	1.33	0.01	0.77	0.01
7.	*Carissa caronda*	1.33	0.00	0.26	0.00
8.	*Cinnamomum malabatrum*	1.33	0.03	2.06	0.02
9.	*Citrus sp.*	1.33	0.00	0.00	0.00
10.	*Cocos nucifera*	1.33	0.02	1.55	0.02
11.	*Embilica officinalis*	2.67	0.01	0.77	0.01
12.	*Eugenia jambos*	4.00	0.03	2.06	0.02
13.	*Fahrenheitia integrifolia*	4.33	0.09	143.27	1.43
14.	*Garcinia gummi-gutta*	1.33	0.02	35.23	0.35
15.	*Embilica officinalis*	12.67	0.05	3.87	0.04
16.	*Lannea coromandelica*	1.33	0.01	1.03	0.01
17.	*Malus pumila*	234.67	0.62	2116.39	21.16
18.	*Mangifera indica*	356.00	0.31	1248.33	12.48
19.	*Michelia champaca*	1.33	0.00	0.00	
20.	*Moringa oleifera*	1.33	0.00	0.00	0.00
21.	*Musa sp..*	2.67	0.00	0.00	0.00
22.	*Psidium guajava*	14.00	0.46	745.94	7.46
23.	*Tamarindus indica*	5.33	0.15	22.81	0.23
24.	*Tectona grandis*	1.33	0.00	0.00	0.00
25.	*Unidentified*	102.67	4.62	15613.45	156.13
26.	*Vitex altissima.*	2.67	0.00	0.00	0.00
	Total	**782.17**	**7.22**	**20290.89**	**203.00**

b) Medium HGs

Sl. No.	Species	Density (individuals/ha)	Mean basal area/ha (m^2/ha)	Mean crown area/ha (m^2/ha)	CLR (%)	Mean height (m)
1.	*Anacardium occidentale*	33.33	0.44	339.12	1.13	21.00
2.	*Annona squamosa*	5.67	0.00	0.00	0.00	0.00
3.	*Areca catechu*	1027.67	7.61	7260.47	72.60	6.00
4.	*Artocarpus communis*	8.33	0.07	62.06	0.62	9.00
5.	*Artocarpus heterophyllus*	12.67	0.03	0.00	0.00	0.00
6.	*Averrhoa bilimbi*	16.67	0.67	301.44	3.01	18.00
7.	*Calophyllum inophyllum*	2.67	0.03	52.33	0.52	4.50
8.	*Carica papaya*	16.67	0.04	52.33	0.52	8.00
9.	*Caryota urens*	5.67	0.10	160.14	1.60	0.00
10.	*Cinnamomum malabatrum*	11.33	0.25	320.28	3.20	0.00
11.	*Citrus sp.*	8.33	0.02	163.54	1.64	5.00
12.	*Cocos nucifera*	214.00	0.25	0.00	0.00	0.00
13.	*Coffea arabica*	2.67	0.01	0.00	0.00	2.50
14.	*Erythrina indica*	5.33	0.02	0.00	0.00	0.00
15.	*Fahrenheitia integrifolia*	8.33	0.12	138.42	1.38	4.00
16.	*Ficus glomerata*	5.67	0.06	40.04	0.40	9.00
17.	*Garcinia gummi-gutta*	16.67	0.09	29.44	0.29	6.54
18.	*Gliricidia sepium*	8.33	0.03	40.89	0.41	12.00
19.	*Ixora coccinia*	16.67	0.07	209.33	2.09	4.50
20.	*Lagerstroemia reginae*	2.67	0.04	85.74	0.86	8.00
21.	*Mangifera indica*	16.67	0.02	0.00	0.00	3.50
22.	*Murraya koenigi*	8.33	1.59	1139.82	11.40	9.00
23.	*Musa sp.*	141.67	1.56	1285.57	12.86	16.50
24.	*Myristica fragrans*.	25.00	1.44	829.16	8.29	12.00
25.	*Piper nigrum*	17.33	0.00	0.00	0.00	4.50
26.	*Spondias pinnata*	5.67	0.18	0.00	0.00	12.50
27.	*Syzygium cumini*	8.33	0.00	0.00	0.00	2.00
28.	*Tamarindus indica*	8.33	0.10	0.00	0.00	1.00
29.	*Tectona grandis*	58.33	2.56	3875.81	38.76	12.00
30.	*Terminalia catappa*	8.33	0.04	150.72	1.51	5.00
31.	*Theobroma cacao*	25.00	0.09	0.00	0.00	3.50
	Total	1752.33	17.52	16536.64	165.37	-

c) Large HGs

Sl. No.	Species	Density (individuals /ha)	Mean basal area (m^2/ha)	Crown area (m^2/ha)	CLR (%)	Height (m)
1.	*Adenanthera pavonina*	3.33	0.08	0.00	0.00	13.00
2.	*Ailanthus triphysa*	67.00	1.64	0.00	0.00	15.00
3.	Alston*ia scholaris*	5.67	0.03	139.50	1.39	4.50
4.	*Anacardium occidentale*	5.00	0.12	19.69	0.20	
5.	*Ananas comosus*	166.67	0.00	0.00	0.00	
6.	*Annona squamosa*	5.67	0.05	0.00	0.00	6.00
7.	*Areca catechu*	585.67	8.03	3604.43	36.04	15.50
8.	*Artocarpus communis*	4.67	0.47	443.26	4.43	13.00
9.	*Artocarpus heterophyllus*	14.67	0.49	1245.28	12.45	13.00
10.	*Artocarpus hirsutus*	10.67	3.00	380.38	3.80	15.00
11.	*Averrhoa bilimbi*	4.67	0.10	131.88	1.32	6.00
12.	*Bombax ceiba*	4.67	0.03	0.00	0.00	5.00
13.	*Caesalpinia coriaria.*	4.67	0.01	0.00	0.00	4.50
14.	*Cananga odorata*	1.67	0.08	31.41	0.31	19.50
15.	*Carica papaya*	3.00	0.00	0.00	0.00	
16.	*Caryota urens*	2.00	0.15	0.00	0.00	16.00
17.	*Citrus sp.*	14.33	0.00	0.00	0.00	1.50
18.	*Cocos nucifera*.	168.67	6.96	9342.38	93.42	18.50
19.	*Coffea arabica*	1.67	0.01	11.78	0.12	3.50
20.	*Erythrina indica*	9.67	0.00	0.00	0.00	1.50
21.	*Eugenia jambos*	9.00	0.08	25.50	0.26	6.00
22.	*Ficus glomerata*	2.67	0.05	0.00	0.00	5.00
23.	*Garcinia gummi-gutta*	5.00	0.12	192.33	1.92	5.50
24.	*Gliricidia sepium*	14.33	0.05	0.00	0.00	6.00
25.	*Gmelina arborea*	3.00	0.57	0.00	0.00	15.00
26.	*Hevea braziliensis*	1.67	0.16	0.00	0.00	19.00
27.	*Hibiscus rosa-sinensis*	14.33	0.00	0.00	0.00	3.50
28.	*Hydnocarpus pentandra*	5.00	1.22	0.00	0.00	18.00
29.	*Jatropha spp.*	14.33	0.03	0.00	0.00	4.50
30.	*Lannea coromandelica.*	7.33	0.06	64.99	0.65	5.00
31.	*Macaranga peltata*	5.67	0.10	71.17	0.71	7.00
32.	*Mangifera indica*.	19.00	3.97	816.75	8.17	17.00
33.	*Musa sp.*	170.67	2.88	4052.69	40.53	3.00
34.	*Myristica fragrans*	14.33	0.12	157.38	1.57	5.50
35.	*Ocimum sanctum*	47.67	0.00	0.00	0.00	1.00
36.	*Piper nigrum*	14.33	0.00	0.00	0.00	
37.	*Plumaria alba*	3.00	0.04	71.24	0.71	5.60

38.	*Psidium guajava*	1.67	0.02	0.00	0.00	4.00
39.	*Syzygium cumini*	4.67	0.10	38.46	0.38	9.00
40.	*Tamarindus indica*	3.00	0.22	74.38	0.74	4.00
41.	*Tectona grandis*	6.33	0.11	0.80	0.01	8.50
42.	*Terminalia catappa*	9.67	0.17	273.18	2.73	8.50
43.	*Theobroma cacao*	11.33	0.15	142.35	1.42	6.50
44.	*Trema orientalis*	1.33	0.18	0.00	0.00	11.50
	Total	1473.33	31.66	21331.21	213.31	-

3. 6. 6.Vertical structure of the HGs

Like other zones vertical structure of HGs was stratified in to 5 stratas viz. S0 (<2m), S1 (2-7m), S2 (7-12m), S3 (12-16m) and S4 (>16m). The maximum mean density per hectare, basal area and crown area were recorded in S1 of small HGs while S4 strata of medium and large HGs had maximum mean density per hectare, basal area and crown area. S1 of small HGs, S4 of medium HGs and large HGs were predominant in terms of mean density per hectare, basal area and crown area (Table 3.6.7. a, b and c).

Table 3.6.7. Vertical structure of homesteads

a) Small HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16 m)
Density (individuals/ha)	65	1474	378	892	16
Mean basal area (m^2/ha)	0.2	25.72	5.97	16.80	01.22
Mean crown area (m^2/ha)	70.20	34938.38	6643.89	18088.07	319.79

b) Medium HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16 m)
Density (individuals/ha)	125	600	550	250	3100
Mean basal area (m^2/ha)	-	04.62	4.96	2.64	80.20
Mean crown area	-	7717.5	5691.6	4069.80	30780

(m^2/ha)					

b) Large HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16 m)
Density (individuals/ha)	129	614	100	314	1086
Mean basal area (m^2/ha)	03	0.31	0.10	0.55	38.02
Mean crown area (m^2/ha)	4.38	84.02	30.50	13.72	49990.16

3.6.7. Interventions in the agroforestry systems

A list of 126 species was distributed to the farmers of the Kole zone. Farmers were suggested 4 type of interventions viz., introduction of annual crops, introduction of MPTs, introduction of medicinal plants, introduction of fruit crops and introduction of plantation/ cash crops for enhancing the productivity of homegardens. Four types of interventions were made in the existing agroforestry systems, a total of 997 seedlings belonging to 76 species were distributed to the 59 households as interventions (Appendix-2). Out of 997, 554 plants of 60 species, 335 plants of 45 species and 108 plants of 29 species were distributed to small HGs, Medium HGs and large HGs, respectively. Of 997 plants, 8% are fruit trees, 7% medicinal plants and plantation crops, 28% spices and 40% trees were included (Table 3.6.8). Monitoring survey showed that about 92 % of 997 plants have survived.

Table 3.6.8. Interventions for new agroforestry models

a) Small HGs

SL. No.	Type of Interventions	No. of species	Quantity (Nos.)	Households (Nos.)
1	Annuals	-	-	-
2	Fruit trees	15	98(18)	50
3	Medicinal plants	15	37(7)	16
4	Plantation crops	4	41(7)	7

5	Spices	5	158(28)	21
6	Trees	21	220(40)	54
	Total	60	554	148

b) Medium HGs

SL. No.	Type of Interventions	No. of species	Quantity (Nos.)	Households (Nos.)
1	Annuals	2	6(2)	2
2	Fruit trees	10	40(12)	20
3	Medicinal plants	11	43(13)	17
4	Plantation crops	3	25(7)	7
5	Spice	4	150(45)	11
6	Trees	15	71(21)	21
	Total	45	335	78

c) Large HGs

SL. No.	Type of Interventions	No. of species	Quantity (Nos.)	Households (Nos.)
1	Annuals	-	-	-
2	Fruit trees	7	7(6)	8
3	Medicinal plants	5	10(9)	5
4	Plantation crops	2	24(22)	2
5	Spice	1	2(2)	1
6	Trees	14	65(61)	16
	Total	29	108	31

(Values in parenthesis show percentage**)**

3.7. Dry -Low rain fall zone

3.7.1. General features

The dry zone covers Attappady hills and eastern parts of Palakkad district of Kerala. The mean average annual rainfall is 960 mm. The mean maximum temperature is 44^0 C in Feb- march. Soil type is inceptisols.

3.7. 2. Size of HGs

Out of 51 randomly selected HGs, small HGs represents 73%, medium 17% and large HGs 10.0% (Table 3.7.1.). The data revealed that small HGs representation was high. This difference may due to continuous fragmentation of land and high population pressure.

Table 3.7.1. Size of homesteads

Category	Households encountered		Total land holding size (ha)	Mean land holding size (ha)
	Nos.	Percentage		
Small HGs	37	73	5.36	0.145
Medium HGs	9	17	6.196	0.688
Large HGs	5	10	11.8	2.36

3.7. 3. Classes of HGs

The data revealed that small HGs had class 1 and class 3 whereas both medium and large HGs had predominantly class 2 and class 3 respectively. The class 1 was observed in small HGs only while class 4 was absent in all HGs (Table 3.7.2.). This difference may be due to the locality factors, local market and farmer's interest.

Table 3.7. 2. Type of homegardens

Type	Number of households encountered (40)		
	Small HG	Medium HG	Large HG
Homegardens alone	24(65%)	-	-
Homegardens cum monoculture	-	1(11%)	3(60%)
Homegardens cum milch animal	13(35%)	8(89%)	2(40%)
Homegardens cum others (fishery/ Apiculture)	-	-	

3.7.4. Income share of homestead and women's role in homestead management

Out of three classes, 1st class (income<25%) was predominantly represented in 81% of small HGs whereas 1st and 3rd classes (income>5%) were recorded in 44% and 60% of medium and large HGs, respectively.

With regard to women's role in homestead management, About 89% of small HGs had class 3 whereas about 67% and 60% of medium and large HGs had class 2 and class 3, respectively (Table 3.7.3).

Table 3.7.3. Homestead's income share and women's role in homestead management

Category	Number of households encountered					
	Income share			Women's role		
	<25%	25-50%	>50%	<25%	25-50%	>50%
Small HGs	30(81)	7(19)	-	-	4(11)	31(89)
Medium HGs	4(44)	3(34)	2(22)	1(11)	5(67)	2(22)
Large HGs	1(20)	1(20)	3(60)	3(60)	1(20)	1(20)

(Parenthesis value show percentage)

3.7. 5. Horizontal structure of HGs

3.7.5.1. Species composition and diversity indices

Based on the major function of plants, the total 38 plant species grouped into 6 groups, which include 4 annuals, 13 fruits, 5 plantation crops, 5 medicinal plants, 3 spices and 8 timber species (Table 3.7.4).

Table 3.7.4. Functional class of plants in homesteads

Category	Spices		Annuals		Fruit crops		Plantation crops		Timber species		Medicinal plants	
	*Spp	Density (Individuals/ha)	*Spp.	Density (Individuals/ha)	*Spp.	Density (Individuals/ha)	*Spp.	Density (Individuals/ha)	*Spp.	Density (Individuals/ha)	*Spp.	Density (Individuals/ha)
Small Hg	-	-	1	133	2	183	4	183	4	767	3	350
Medium Hg	2	147	2	293	8	95	3	860	3	202	3	23
Large Hg	3	67	5	745	6	411	3	1095	5	495	5	268
Mean total	3	71	4	390	13	230	5	713	8	488	5	214

(* Actual species number)

The data on species composition and diversity indices revealed that out of 38 encountered plant species, eight common species were recorded in the HGs. A total of six, 13 and 19 species were exclusively recorded in small HGs, medium HGs and large HGs, respectively. In case of diversity indices, the high value of mean Simpson's index diversity index (D) and Shannon- Wiener diversity index (H') were observed in large and small HGs respectively and the low value of both D and H' was recorded in medium HGs. The low value of D shows that medium HGs flora was shared by many species than others. The high value of H' indicates that flora of small farms was more stable than others (Table 3.7.5).

Table 3.7.5. Species diversity and diversity indices in homegardens

Class	No.of species	Dominance index (Ds)	Shannon- Wiener index (H')
Small HG	14	0.882	1.183
Medium HG	21	0.822	0.926
Large HG	27	0.910	1.094
Total	38		

(Common species in small medium and large HGs**:** 8)

3.7.5.2. Community structure of HGs

Data on density, basal area, crown area, CLR (Crown Land Ratio) and mean height are furnished in Table 3.7.6. (a, b & c). The High mean density (2239.27 individuals /ha) and mean basal area (64.50 m^2/ha) were in large HGs and small HGs respectively, whereas high value of mean crown area (22282.31 m^2/ha) was recorded in small HGs. Low values of mean density (1133.33 /ha) and mean basal area (14.70m^2/ha)were recorded in small and medium HGs, respectively. The low mean crown area (9353.75 m^2/ha) was in medium HGs. The maximum CLR (222.82%) was recorded in small HGs followed by large (139.10%) and medium HGs (93.53%). The high value of CLR of small HGs showed that the degree of overlapping in the different strata of canopy of the homegardens due to lack of space. By and large, coconut (*Cocos nucifera* L.), mango (*Mangifera indica),* neem *(*Azadirachta indica), nelli *(Embilica officinalis),* Jack *(Artocarpus heterophyllus), t*amarind *(Tamarindus indica), Areca catechu,* teak *(Tectona grandis),* and Indian-silk-cotton *(Bombax ceiba)* were dominant species in all categories of homegardens in terms of density, crown area and basal area.

Table 3.7.6. Species diversity, certain biometric parameters and community structure of homegardens

a) Small HGs

Sl. No.	Species	Density (individuals /ha)	Basal area (m^2/ha)	Crown area (m^2/ha)	CLR (%)	Height (m)
1.	*Anacardium occidentale*	16.67	0.30	213.69	2.14	4.50
2.	*Areca catechu.*	33.33	0.00	2.18	0.02	1.00
3.	*Azadirachta indica*	166.67	22.61	4019.20	22.00	7.83
4.	*Bombax ceiba*	50.00	1.15	471.00	4.71	8.00
5.	*Cocos nucifera*	216.67	19.07	6860.03	158.00	12.50
6.	*Dalbergia latifolia*	33.33	0.00	3.14	0.03	1.00
7.	*Emblica officinalis*	150.00	9.04	4749.25	38.50	9.00
8.	*Luecaena leucocephala.*	50.00	0.18	471.00	4.71	6.50
9.	*Mangifera indica*	150.00	8.31	4749.25	49.10	8.50
10.	*Haldina cordifolia*	16.67	0.30	39.25	0.39	4.00
11.	*Moringa oleifera*	33.33	0.10	19.63	0.20	6.00
12.	*Musa sp.*	133.33	1.32	0.00	0.00	3.00
13.	*Tamarindus indica*	16.67	1.77	527.69	5.28	9.00
14.	*Tectona grandis.*	66.67	0.37	157.00	1.57	8.50
	Total	1133.33	64.50	22282.31	222.82	

b). Medium HGs

Sl. No.	Species	Density (Individuals/ha)	Basal area (m^2/ha)	Crown area (m^2/ha)	CLR (%)	Mean height (m)
1.	*Achras sapota*	8.6	0.04	75.0111	0.75	3.167
2.	*Areca catechu*	508.33	1.87	399.042	3.99	6.667
3.	*Artocarpus heterophyllus*	22.567	0.43	217.007	2.17	10.17
4.	*Azadirachta indica*	14.733	0.04	1.28507	0.01	3.5
5.	*Borassus flabellifer*	0.6944	0	0.06057	0	4.00
6.	*Cassia fistula*	26.667	0.06	2.32593	0.02	0.667
7.	*Cinnamomum malabatrum*	6.6667	0	0.000	0	0.00
8.	*Citrus sp*	33.333	0.02	26.1667	0.26	1.167
9.	*Cocos nucifera*	225.33	10.9	7861.63	78.6	13.67
10.	*Erythrina indica*	66.667	0.11	0.00	0	1.667
11.	*Amorphophalus sp.*	166.67	0.00	0.00	0	0.00
12.	*Mangifera indica*	61	0.57	532.056	5.32	6.333
13.	*Haldina cordifolia*	0.6944	0.00	0.06057	0	1.667

14.	*Moringa oleifera*	2.7778	0.00	0.96914	0.01	1.5
15.	*Musa sp.*	126.33	0.35	11.0191	0.11	1.667
16.	*Piper nigrum* L.	140	0.00	0.00	0.00	0.00
17.	*Psidium guajava L*	20.7	0.15	64.998	0.65	2.417
18.	*Punica granatum*	4.6333	0.02	58.1947	0.58	2.333
19.	*Syzygium cumini (*L.*)* Merr.& Perry.	1.9231	0.01	10.735	0.11	5.00
20.	*Tamarindus indica* L.	8.8	0.13	92.8742	0.93	7.167
21.	*Tectona grandis* L.f.	22.436	0.00	0.31311	0.00	0.333
	Total	1469.6	14.7	9353.75		

c) Large HGs

SL. No.	Species	Density (individuals/ha)	Basal area (m^2/ha)	Crown area (m^2/ha)	CLR (%)	Mean height (m)
1.	*Areca catechu*	150.00	1.27	117.75	1.18	6.83
2.	*Artocarpus heterophyllus*	16.67	0.06	23.26	0.23	6.00
3.	*Azadirachta indica*	127.67	0.80	121.26	1.21	4.17
4.	*Borassus floplifrus*	5.57	0.12	1.09	0.01	3.33
5.	*Carica papaya*	66.67	0.03	0.00	0.00	2.00
6.	*Cinnamomum malabatrum*	5.57	0.00	0.17	0.00	0.33
7.	*Citrus sp.*	11.10	0.00	0.35	0.00	0.33
8.	*Cocos nucifera*	355.67	22.77	10051.14	100.51	10.50
9.	*Dalbergia latifolia*	5.57	0.00	0.12	0.00	0.43
10.	*Emblica officinalis*	100.00	0.57	787.18	7.87	3.83
11.	*Gliricidia sepium*	61.00	0.01	5.32	0.05	0.50
12.	*Coccinia* spp.	16.67	0.00	0.00	0.00	0.00
13.	*Mangifera indica*	89.00	2.33	1414.77	14.15	4.33
14.	Manihot esculenta			0.00	0.00	0.00
15.	*Michelia champaca*	16.67	0.02	23.26	0.23	2.00
16.	*Erythrina indica*	16.67	0.07	5.81	0.06	2.17
17.	*Moringa oleifera*	5.57	0.00	0.24	0.00	0.33
18.	*Morus alba*	16.67	0.01	5.81	0.06	1.67
19.	*Murraya koenigii*	16.67	0.00	0.00	0.00	2.17
20.	*Musa paradisiacal*	589.00	2.44	462.37	4.62	2.50
21.	*Myristica fragrans.*	44.33	0.04	15.47	0.15	1.33
22.	*Malus pumila*.	5.57	0.00	0.00	0.00	0.00
23.	*Piper nigrum*	16.67	0.00	0.00	0.00	0.00
24.	*Psidium guajava*	194.33	1.39	830.56	8.31	4.27
25.	*Colocasia esculenta*	133.33	0.00	0.00	0.00	0.00
26.	*Strychnos nux-vomica*	16.67	0.00	0.00	0.00	0.00
27.	*Tectona grandis*	139.00	0.89	31.04	0.31	6.00

28.	*Terminalia tomentosa*	16.67	0.02	13.08	0.13	3.33
	Total	2239.27	32.87	13910.06	139.10	

3.7. 6. Vertical structure of the HGs

This study reveals that high mean density (600 individuals/ha), basal area (43.24 m^2/ha) and crown area (14673.4 m^2/ha) were recorded in S2 of small HGs. Maximum basal area (10.92 m^2/ha) and crown area (7861.63 m^2/ha) of medium HGs were recorded in S3 whereas high mean density (750 individuals /ha) was recorded in S1 of medium HGs. In case of large HGs, the high value of basal area (22.77 m^2/ha) and crown area (10051.14 m^2/ha) were noted in S2 and high mean density (1544.57 individuals /ha) was recorded in S1 stratum (Table 3.7.7). It was concluded that medium HGs had number of tall trees (12-16 m) whereas small and large HGs were made of woody plants with height of 7-12 m. This may be due to the fact that medium HGs had well-developed old plants and got maximum managerial inputs.

Table 3.7.7. Vertical structure of homesteads

a) Small HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16 m)
Mean density (individuals /ha)	67.00	250.00	600.00	217.00	-
Mean basal area (m^2/ha)	-	2.19	43.24	19.07	-
Mean crown area (m^2/ha)	5.32	743.57	14673.39	6860.03	-

b) Medium HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16m)
Mean density (individuals/ha)	462.00	750.00	31.00	225.33	-
Mean basal area (m^2/ha)	0.20	3.06	0.56	10.92	-

Mean crown area (m^2/ha)	28.81	1153.43	309.88	7861.63	-

b) Large HGs

Parameter	Strata				
	S0 (<2 m)	S1 (2-7 m)	S2 (7-12 m)	S3 (12-16 m)	S4 (>16 m)
Mean density (individuals /ha)	339	1544.57	355.67	-	-
Mean basal area (m^2/ha)	0.07	10.03	22.77	-	-
Mean crown area (m^2/ha)	27.49	3831.43	10051.14	-	-

6.7.7. Interventions in the agroforestry systems

A list of 126 species was distributed to farmers. Farmers were suggested four types of interventions viz., introduction of annual crops, introduction of MPTs, introduction of medicinal plants, introduction of fruit crops and introduction of plantation/ cash crops for enhancing the productivity of homegardens. A total of 2076 seedlings were distributed to the 35 households as interventions to develop new agroforestry models (Appendix-2). Of 2076 seedlings, 736 plants belonged to 83 species, 697 plants belonged to71 and 643 plants belonged to 54 species. The total 2076 plants consist of 21, 228,164, 101, 201, and 1089 annuals, fruit crops, medicinal plants, plantation crops, spices and tree species, respectively (Table 3.7.8). The survival percentage of intervened plants was about 78.5 (Plate 7-9).

Table 3.7.8. Interventions for new agroforestry models

a) Small HG

SL. No.	Type of Interventions	No. of species	Quantity (Nos.)	Households (Nos.)
1	Annuals	6	15	11
2	Fruit trees	15	150	63
3	Medicinal plants	25	91	76
4	Plantation crops	3	56	10
5	Spices	6	62	19
6	Trees	28	362	93
	Total	83	736	272

b) Medium HGs

SL. No.	Type of Interventions	No. of species	Quantity (Nos.)	Households (Nos.)
1	Annuals	3	6	2
2	Fruit trees	14	66	31
3	Medicinal plants	24	45	34
4	Plantation crops	3	32	4
5	Spices	5	36	52
6	Trees	22	512	7
	Total	71	697	130

c). Large HGs

SL. No.	Type of Interventions	No. of species	Quantity (Nos.)	Households (Nos.)
1	Annuals	-	-	-
2	Fruit trees	12	112	39
3	Medicinal plants	12	78	37
4	Plantation crops	2	13	3
5	Spices	5	103	15
6	Trees	23	415	61
	Total	54	643	155

3.8. General discussion

3.8.1. Southern Zone

In the southern zone bulk of the HGs are of small size and comprise of homestead alone while medium and large HGs have monoculture crops and also milch animal. Only medium and large HGs provide more than 50% of the family income. The density of the crops is higher in small HGs and gets reduced with increasing size of the HGs. Simpson's diversity index and Shannon –Weiner index are higher in small HGs. Further, basal area and CLR are higher in small HGs. Regarding vertical structure in the HGs, space is available in less than 2 m and greater than 16 m in both medium and large HGs. In the HGs survey, small HGs had 30, medium 13 and large 11 tree species. A declining trend in the homesteads farming was observed in this zone due to labour scarcity, failures of market, Govt policy, etc.. Interventions were not attempted.

3.8.2. Central Zone

Although small HGs predominate, medium and large HGs are present (52%) revealing a change in land holding size. Smaller HGs are the ones with homestead alone and homestead with milch animal. Only large HGs possess monoculture crops. Medium and large HGs provide more than 50% income share to the family. Species diversity index and Shannon – Weiner index are higher in medium and large HGs respectively. Density and basal area are higher in medium and large HGs, respectively while CLR is higher in large HGs. With reference to vertical space availability, it is available in more than 16 m in small HGs and less than 2 m in medium and large HGs. Regarding interventions the farmers preferred to plant fruit and tree species in their HGs.

3.8.3. Northern Zone

With reference to size of HGs, Northern zone has more number of large HGs (52%). Most HGs are of homesteads plus animal husbandry. Small HGs provide only 25-50% of the total income. The index of diversity and

Shannon –Weiner index are the highest in large HGs. Regarding density and basal area, small HGs have higher values whereas highest crown area was recorded in large HGs. We encountered 10 tree species in small, 14 in medium and 19 in large HGs. Regarding vertical space, all size classes of HGs have gap in the category, above 16 m, revealing possibility of introducing interventions in this zone.

3.8.4. High range Zone

In high range zone**,** HGs are predominantly made by small and medium HGs. Small HGs comprise of homesteads alone while large HGs have monoculture plantation. All three categories have homestead combined with animal husbandry. Income share from HGs is low (<25%) in small HGs while it is above 50% in medium and large HGs. Both index of diversity and Shannon – Weiner index are highest in large HGs. Rubber is absent in this zone. Both small and large HGs had 10 tree species whereas medium had 21 tree species. High density and basal area were noted in large HGs and these were low in small HGs. In all HGs vertical space is available in the category above 16m. Regarding interventions, nearly about 70 species of plants were accepted by all farmers, prominently, medicinal, fruit and tree species.

3.8.5. Onattukara

In this zone, bulk of HGs comprise of small HGs and homesteads alone account for maximum. Homesteads with monoculture and homesteads with animal husbandry are more in medium and large HGs. Small HGs provide less than 25% of the family income. Medium and large HGs tend to contribute more than 50% income to the family. Crop diversity is higher in large HGs while Shannon Wiener index is maximum in small HGs. With regard to planting density and CLR large HGs have higher values than small and medium HGs. Most of the strata are closely filled in all types of HGs.

3.8.6 Kole zone

In this zone, small HGs are dominant. Homesteads alone and homesteads with animal husbandry are present. Medium and large HGs provide more than 50% income to the family. Medium HGs have higher species diversity and small HGs have lowest species diversity. Planting density is highest in large HGs. But CLR tends to be same in small and large HGs. In the vertical plane, space is available in S4 of small HGs, S0 of Medium HGs and S2 and S3 of large HGs. Regarding interventions, farmers preferred fruit, medicinal and tree species.

3.8.7. Low rainfall (dry) Zone

In this zone, small HGs are predominant. Homesteads with monoculture and homestead with animal husbandry are more in medium and large HGs categories. Only large HGs provide more than 50% of the family income. Species diversity is highest in large HGs with 27 species. Density of planting is highest in large HGs while CLR is highest in small HGs. In the vertical plane, space is available in the categories of HGs in the height class 12-16 m and above 16 m. Interventions wise, farmers preferred medicinal and forest tree species.

4. HOMEGARDEN MODELS

4.1. Introduction

Recent years have witnessed degeneration in the homegarden systems. Change in the land ownership pattern, ever reducing holding size and fragmentation, tendency to shift from subsistence/ poly cropping to market oriented/ mono cropping systems, entry of commercial crops, monoculture plantations are major influencing factors which have induced the degradation. The land resources and the capital are often under utilised, as the labour force is not available. Willingness for diverting income from other sources as interventions for maintenance/management of homesteads has often severe restrictions, as the labour is a limiting resource. Here again the situation varies, as the majority of the homesteads in the lowland are not farm dependant. In the contrary, the homesteads of the highlands are dependant. It is a reality that 70 % of the timber requirement, demand for fuel wood, fodder, green manure and poles are met from the homesteads. The changing concept from subsistence to economically viable alternatives through monocultures has affected this supply of an array of species. Disappearance of these species from the homesteads is of serious concern.

Even though mixed farming systems comprising seasonal and perennial crops, plants and trees, and also with a variety of animals and birds are perceived with many added on benefits and social acceptance due to economic reasons, these systems are found to be non-viable. Intercropping in coconut has not been considered as a viable option by a majority of small, medium and large farmers. To tackle the situation, for managing the sharp decline or fluctuation of prices for the agricultural products and also to manage the pest attack or other uncertainties which affect the total output of any particular crop, farmers prefer to have a specific space assigned to each crop. This is more or less a mosaic of monocultures within the homesteads. This system is strictly followed by a majority of coconut and arecanut growers by allowing nothing to grow in between.

Declining prices and drastic fluctuations in market demand discourage farmers from any intervention, maintenance or management of their homestead units. Existing labour groups are posed with a threat of unemployment often searching for other

employment opportunities. This will again aggravate the situation of non-availability of labour force.

Thus the models proposed are within the already existing framework of homesteads, but with variations in the species choice. Each model is proposed for an area of 0.4 ha (one acre). Species composition of the different models is provided in Tables 4.1 and 4.2. Diagrammatic representation of the models is provided in Figures 4.1 to 4.5

The species incorporated into the model are categorised into:

1. Timber yielding species viz. *Tectona grandis* (teak), *Artocarpus hirsutus* (anjily*), Swietenia mahogany* (mahogany), *Xylia xylocarpa* (irumullu*), Albizia odoratissima* (kunnivaka), *Dalbergia sp* (veeti) and *Ailanthus* sp.(matti)
2. Green manure, viz. T*erminalia paniculata* (maruthu) *T. bellirica* (thanni), *Erythrina indica, (*murikku), *Gliricidia* (seemakonna) etc
3. Fruit yielding viz. mango, jack, guava, tamarind, kudampuli, *Phyllanthus* sp. etc.
4. Cash crops viz. coconut, areca, nutmeg, cashew, coffee, tapioca, banana, bamboo, pepper, etc.
5. Space allocated for the kitchen garden is proposed to have trees like papaya, muringa, *Garcinia sp.*, tamarind, etc, along with annuals and perennials including vegetables.

6. Four species of bamboo in the corners to meet the requirement of household uses and for the market suggested include *Bambusa bambos* (mullumula), *Thyrsostachys oliveri*(lathimula), *Bambusa balcooa* (Assam mula) and *Dendrocalamus strictus* (kallan mula). In the tree-based model one more species of bamboo, *Dendrocalamus giganteus,* is absorbed.

4.2 Coconut based homestead model

Coconut based homesteads are the most dominant and preferred ones. Regular monthly income and the multi-use value of coconut palm have helped to place itself well in the homesteads and in the minds of the people.

The model with a coconut based one is with a spacing 7.5x7.5 m . Timber yielding varieties, fruit yielding varieties and species that provide high quality green manure are planted along the border. The model has absorbed 31 coconut trees and 38 arecanut palms, 21 nutmegs in the interspacing of coconut and 26 bananas in the interspacing of arecanut. Arecanut is planted along the border with pepper grown on it. Pepper is also proposed on the timber species, species providing green manure and *Gliricidia* sp. (seemakonna) planted along the fringes. Pepper, as a promising crop, which does not require separate spacing of its own, was absorbed at the maximum level. Pepper enjoys a good price in the market. Given the adequate protection and measures at the right time diseases can be controlled. Timely monsoon rains and plant protection can guarantee good productivity of pepper and therefore can be ideally recommended as a component of homestead.

Due to constraints in labour, decline in prices and considering the inputs, instead of maximising the number of coconut palms, tree species with multipurpose values have been incorporated. Besides providing support for pepper, *Terminalia paniculata* (maruthu), *T. bellirica* (thanni), *Gliricidia sp* (seemakonna), *Erythrina s*p. (murikku) etc are the most preferred ones and are potential sources of green manure. Criteria for selection of multipurpose species was to ensure self-sufficiency of fuel wood, fodder, green manure, poles, good quality timber, and fruit yields. There is also an increasing interest shown towards planting timber species like teak, mahogany and anjily especially by the farm independent homesteads, as these species with minimum input, fetch high returns. Marketing is not a constraint as there is a good demand and purchasing is done at the doorsteps.

There are 13 timber trees with three anjily, teak and mahogany each and one species each of *Xylia xylocarpa* (irumullu), *Albizia odoratissima* (kunnivaka), *Dalbergia latifolia* (veeti) and *Ailanthus sp*. (matti)

Twelve fruit trees include three jack and mango each, one each of tamarind and *Garcinia* (kudampuly) and two each of muringa and papaya in the kitchen garden. Kitchen garden with annuals and perennials include vegetables. *Gliricidia* planted along the fringes provides support for pepper, fixes nitrogen and is a good source of green manure. (Fig.4.1)

Arecanut based homestead model

Arecanut based homestead is a cash crop dominant model. Arecanut is incorporated into the model with banana grown in the interspace. A total of 91 banana plants are provided. Fourteen coconut palms have been included, mainly to meet the household needs. In the interspace of coconut, seven nutmegs are included. A total of 251 members of cash crops are provided. Pepper is supported on all the timber species, including species planted for green manure, which accounts to a total of 25 plants. Total individuals of tree species included in the model are 332. (Fig.4.2)

Coffee based homestead model

Coffee based one is a typical highland and a cash crop dominant model. One hundred and thirteen coffee plants have been included in the model. Incorporation of tree species into the model as shelter for coffee and for growing pepper is anjily (48), *Erythrina sp.*(64) and *Gliricidia sp.* (48). *Erythrina* sp. and *Gliricidia sp.* are efficient nitrogen fixers and green manure obtained is of high quality. Anjily is the most preferred tree in this zone as the timber fetches good returns. Pepper and other cash crops are at the maximum when compared to the other models. A variety of tree species are also included in this model.

Even though there is a higher quantum of home labour involvement in the homesteads of highland than in the low and midlands, the input in terms of labour and money has been drastically reduced due to the sharp decline in market prices of agricultural products produced in this zone. Introduction of forest trees or retaining forest trees in the homesteads (either encroached or with forest tree species) is an indicator of change in selecting less labour intensive agricultural crops and high value timber species. (Fig. 4.3)

Mixed homestead model

Mixed model is a cash crop dominant model. Species composition is almost same with cashew being incorporated into the model. Farming cashew with minimum input of labour and other resources (irrigation, fertilisers and pesticides) fetches good and

relatively consistent returns. Nine cashew, 11 coconuts, 58 arecanut, eight nutmegs and 60 bananas have been included in this model. (Fig. 4.4)

Table 4.1. Species composition in different homestead models

Sl.No	Species	Coconut based	Arecanut based	Coffee based	Mixed
1.	Coconut	31	14	8	11
2.	Arecanut	38	110	23	58
3.	Nutmeg	21	7	0	8
4.	Banana	26	91	9	60
5.	Coffee	0	0	113	0
6.	Cashew	0	0	0	9
7.	Bamboo	4	4	4	4
8.	Pepper	26	25	133	43
	Total (cash crops)	146	251	290	193
9.	Anjily	3	3	48	3
10	Teak	3	3	3	3
11	Mahogany	3	3	3	3
12	Xylia	1	1	1	1
12	Albizia	1	1	1	1
13	Rosewood	1	1	1	1
14	Ailanthus	1	1	1	2
	Total (timber)	13	13	58	14
15	Mango	3	3	2	3
16	Jack	3	3	3	3
17	Tamarind	1	1	1	1
18	Garcinia	1	2	0	1
19	Muringa	2	2	2	2
20	Pappaya	2	2	2	2
	Total (fruit bearing)	12	13	10	12
21	Maruthu	2	2	3	5
22	Thani	2	2	3	4
23	Erythrina	3	3	64	15
24	Gliricidia	65	46	48	61
25	Lannea	2	1	1	1
26	Venga	1	1	1	1
	Total (green manure)	75	55	120	87
	Total	246	332	478	306

Tree based homestead model

It is high time a drastic change is made in the existing homestead model, which consists predominantly coconut, arecanut, rubber, cashew etc. Our interaction with farmers in the seven agroclimatic zones of Kerala revealed their strong reluctance to change the existing pattern mainly due to social and cultural acceptance and of course a feeling of familiarity. Over planting with coconut, arecanut and total adoption of rubber in monoculture due to high market value in the past is still being continued. There is a strong apprehension to make a paradigm shift.

In this context we propose a model – a model for tree-growing farmer. Certain vital species of the existing system viz., coconut, jack, mango, etc., are retained but their numbers are reduced to bare minimum.

This model is ideal for farm independent households. Regions where labour restrictions prevail, or where alternative income source exists, or households with minimum attention towards homesteads in terms of interest or money being diverted or for households with losing interest towards cash crops or one who would wish to bring in diversity of trees within homesteads, etc. can adopt this model. Species composition of this model is presented in Table 4.2.

There are 146 plant individuals belonging to 46 species included in this model. Thirty two individuals for timber from eight species, 22 individuals which are fruit yielding ones from 12 species, 27 individuals which can provide green manure from six species. There are 49 individuals for cash crops from four species. Five coconut palms are provided just to meet the household uses. In the interspace six nutmegs are absorbed. There are 5 species of bamboo planted along the periphery. There are 32 banana also being absorbed. There are 16 miscellaneous trees from 12 species for their medicinal and ornamental uses and spices including pepper which can fetch good returns. Annuals and perennials are included in this model with trees as support for the climbers (Fig. 4.5).

Table. 4.2. Species composition in the tree based homestead model

Common name	Scientific name	Number of individuals
Timber		
Teak	*Tectona grandis*	8
Anjily	*Artocarpus hirsutus*	4
Mahogany	*Swietenia macrophylla*	3
Irumullu	*Xylia xylocarpa*	2
Kunnivaka	*Albizia odoratissima*	1
Veeti	*Dalbergia latifolia*	2
Matti	*Ailanthus triphysa*	11
Elavu	*Bombax ceiba*	1
Total		32
Fruit trees		
Mango	*Mangifera indica*	4
Jack	*Artocarpus integrifolia*	5
Kudampuly	*Garcinia gummi-gutta*	1
Muringa	*Moringa oleifera*	1
Pappaya	*Carica papaya*	2
Nelly	*Emblica officinalis*	2
Ambazham	*Spondias pinnata*	2
Irumbanpully	*Averrhoa bilimbi*	1
Attachakka	*Artocarpus communis*	1
Bread fruit	*Annona squamosa*	1
Sapota	*Achras sapota*	1
Total		21
Green manure		
Maruthu	*Terminalia paniculata*	3
Thani	*Terminalia bellirica*	2
Murikku	*Erythrina stricta*	2
Seemakonna	*Gliricidia sp.*	18
Kalasu	*Lannea coromandelica*	1
Venga	*Pterocarpus marsupium*	1
Total		27
Cash crops		
Coconut	*Cocos nucifera*	5
Nutmeg	*Myristica fragrans*	6
Banana	*Musa sp.*	33
Bamboo	5 spp.	5
Total		49
Miscellaneous		

Asokam	*Saraca asoka*	1
Intaa	*Cycas sp.*	1
Toddy palm	*Caryota urens*	1
Marotti	*Hydnocarpus pentandra*	5
Koovalam	*Aegle marmelos*	1
Karinjota	*Samadeera indica*	1
Ungu	*Pongamia pinnata*	1
Clove	*Eugenia caryophyllata*	1
Soap nut	*Sapindus trifoliata*	1
Karuva patta	*Cinnamomum zeylanicum*	1
Elenji	*Mimusops elengi*	1
Kanikonna	*Cassia fistula*	1
Total		16
Grand Total		146

5. CONCLUSIONS

A survey of homegardens (HGs) in seven agroclimatic zones and an attempt to intervene in four agroclimatic zones through introduction of certain plant species permitted to arrive at the following conclusions:

1. Homegardens (HGs), irrespective of agroclimatic zones, can be classified into small, medium and large according to size of land holding. In most agroclimatic zones, small homegardens dominate except in the northern zone.
2. Medium and large homegardens contribute 25-50% and more than 50% of the annual family income, respectively while small homegardens are of subsistence in nature.
3. All types of homegardens are biodiversity wise rich and tree species dominates which constitutes 82% of the total species (Appendix-1), while large homegardens are more diverse. The diversity is stable as revealed by Shannon-Weiner Index.
4. Large and medium homegardens tend to be with monoculture cropping and accommodate animal husbandry in northern, southern and central zones. Coconut, rubber and arecanut are the dominant crops except in High range zone where coffee, cocoa and arecanut take the lead.
5. Plant density and crown land ratio are high in small homegardens and gaps in vertical space are almost absent. There is provision to introduce more tree crops in medium and large homegardens than in small homegardens.
6. Farmers prefer fruit trees, multipurpose tree species and medicinal plants and are willing to introduce these into the existing homegarden set up. The project has introduced a variety of plant species in a few homegardens as a part of the intervention programme and initial observations reveal success (Appendix-2).
7. The shift from homegardens to monocrop and the resultant degeneration are accelerated by failures in government policies, market disfunctioning, and lack of information facilities.

8. Within the existing framework of homesteads, with variations in the species choice, five homestead models are proposed. Preference of farmers in growing multipurpose trees and incorporation of annuals and perennials has been recognized while designing the model. Tree species proposed are intended to provide an array of indirect benefits and also will ensure self-sufficiency in the case of food, fuel wood, fodder, green manure, poles, fruit yields, good quality timber and considerable good returns from the cash crops.

6. RECOMMENDATIONS

In order to shift the present subsistence type of homegardens into more viable commercial enterprises retaining the biodiversity, social and cultural values and ecological benefits, the following recommendations are made:

1. Incentives for improved agroforestry practices - provide subsidy to homegardens that sustain high level of biodiversity. Compensate farmers for maintaining biodiversity by providing avenues for value addition and development of production.
2. Change in governmental/policy failure – Change the Forest Acts and rules, which discourage farmers to grow forest species. Subsidies for cash crops alone may be reconsidered. Land reforms in Kerala, which exempted only plantation crops, have been detrimental to the homegarden existence.
3. Strengthening market signals - The world is experiencing market signals which promote biodiversity and homegarden type of small farmers. These signals viz., nature 'organic' products, certification, value addition, export, etc. can be used to strengthen and network producers and consumers.
4. Need for information dissemination - There is an urgent need to disseminate information on the ecological, social, cultural and economic benefits of homegardens and methods to conserve and use these for economic growth.
5. Institutional set up - An organization to network the introduction of trees into homegardens, develop package of practices, help assess values, certify, value additions and market is the need of the day. The Kerala Forest Department can play a very important role in promoting agroforestry in homegardens.

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APPENDIX 1

Tree species found in the Homegardens of Kerala

Sl.No.	Botanical Name	Local Name
1.	*Acacia mangium*	Mangium
2.	*Achras sapota*	Sapota
3.	*Adenanthera pavonina*	Manchadi
4.	*Ailanthus triphysa*	Matti (Perumaram)
5.	*Albizia lebbeck*	Vaka
6.	*Alstonia scholaris*	Ezhilampala
7.	*Anacardium occidentale*	Kashumavu
8.	*Annona squamosa*	Atha
9.	*Areca catechu*	Kavungu
10.	*Artocarpus communis*	Seemaplavu
11.	*Artocarpus heterophyllus*	Plavu
12.	*Artocarpus hirsutus*	Ayani
13.	*Averrhoa bilimbi*	Irumpanpuli
14.	*Azadirachta indica*	Aryavepu
15.	*Bambusa vulgaris*	Manjamula
16.	*Bombax ceiba.*	Elavu
17.	*Bridelia airy- shawii*	Mulkainy
18.	*Caesalpinia coriaria*	Divi divi
19.	*Calophyllum inophyllum*	Punna
20.	*Cananga odorata*	Lanki
21.	*Carica papaya*	Pappaya
22.	*Caryota urens*	Pana
23.	*Cassia fistula*	Kanikonna
24.	*Cerebra odollam*	Othalam
25.	*Chrysophyllum cainito*	Star Apple
26.	*Cica disticha*	Nellippuli
27.	*Cinnamomum riparium*	Vayana
28.	*Cinnamomum malabatrum*	Karuvapatta
29.	*Citrus aurantifolium*	Narakam
30.	*Cocos nucifera*	Thengu
31.	*Dalbergia latifolia*	Eetty
32.	*Elaeocarpus glandulosus*	Kara
33.	*Emblica officinalis*	Nelli
34.	*Erythrina indica*	Murukku
35.	*Fahrenheitia integrifolia*	Mavilanka
36.	*Ficus glomerata*	Athy
37.	*Flacourtia jangomas*	Vayyam kaitha

38.	*Gliricidia sepium*	Seemakonna
39.	*Gmelina arborea*	Kumizhu
40.	*Grevillea robusta*	Silver oak
41.	*Haldina cordifolia*	Manjakadambu
42.	*Hevea braziliensis*	Rubber
43.	*Hydnocarpus pentandra*	Marotty
44.	*Lagerstroemia reginae*	Manimaruthu
45.	*Lannea coromandelica*	Kalasu
46.	*Leucaena leucocephala*	Sibabul
47.	*Macaranga peltata*	Vatta
48.	*Malus pumila*	Apple
49.	*Mangifera indica*	Mavu
50.	*Michelia chambaca*	Chembakam
51.	*Morinda tinctoria*	Manjanathi
52.	*Moringa oleifera*	Muringa
53.	*Murraya koenigii*	Kariveppu
54.	*Myristica fragrans*	Jathy
55.	*Plumaria alba*	Champakam
56.	*Polyalthia longifolia*	Aranamaram
57.	*Psidium guajava*	Pera
58.	*Pterocarpus marsupium*	Venga
59.	*Punica granatum.*	Mathalam
60.	*Santalum album*	Sandal
61.	*Saraca asoka*	Asokam
62.	*Spondias pinnata*.	Ambazham
63.	*Strychnos nux-vomica*	Kanjiram
64.	*Swietenia mahagoni*	Mahagony
65.	*Syzygium cumini*	Njaval
66.	*Syzygium aromaticum*	Grampoo
67.	*Tabernaemontana heyneana*	Kundalapala
68.	*Tamarindus indica*	Valanpuli
69.	*Tectona grandis*	Thekku
70.	*Terminalia catappa*	Badam (Thallithenga)
71.	*Terminalia paniculata*	Maruthu
72.	*Thespesia populnea*	Poovarassu
73.	*Trema orientalis*	Aamathali
74.	*Vitex altissima*	Karinochi

APPENDIX 2

Tree species seedlings distributed to the farmers

Sl. No.	Botanical Name	Local Name	D	H	K	C	Total
1	*Acacia mangium*	Mangium	131	227	34	55	447
2	*Achras sapota*	Sapota	21	18	3	28	70
3	*Adenanthera pavonina*	Manchady	0	5	0	0	5
4	*Ailanthus triphysa*	Matti	80	0	0	2	82
5	*Albizia lebbeck*	Vaka	16	5	0	0	21
6	*Anacardium occidentale*	Kshumavu	82	62	31	51	226
7	*Annona squamosa*	Atha	15	2	0	0	17
8	*Areca catechu*	Kavungu	69	85	26	75	225
9	*Artocarpus communis*	Kadaplavu	13	25	6	3	47
10	*Artocarpus heterophyllus*	Plavu	44	0	15	7	66
11	*Averrhoa bilimbi*	Erumbanpuli	8	4	1	1	14
12	*Azadirachta indica*	Aryaveppu	2	38	5	6	51
13	*Bambusa bambos*	Mula	162	15	48	0	225
14	*Bambusa vulgaris*	Manjamula	0	0	8	6	14
15	*Bauhinia sp.*	Mandaram	20	9	0	0	29
16	*Caesalpinia coriaria*	Divi-divi	6	5	2	0	13
17	*Cassia fistula*	Kanikonna	10	13	4	0	27
18	*Casuarina equisitifolia*	Kattady	40	5	15	10	70
19	*Cinnamomum zeylanicum*	Karuvapatta	19	44	4	9	76
20	*Citrus aurantifolia*	Narakam	23	10	5	1	39
21	*Citrus lemon*	Cherunarakam	36	32	6	18	92
22	*Clausena indica*	Kattumudiri	5	0	3	4	12
23	*Cocos nucifera*	Thengu	34	92	4	23	153
24	*Dalbergia latifolia*	Eetti	64	24	37	11	136
25	*Dendrocalamus strictus*	Kallanmula	20	0	5	17	42
26	*Emblica officinalis*	Nelli	79	22	19	5	125
27	*Eucalyptus sp.*	Eucaly	20	166	0	12	198
28	*Eugenia aromaticum*	Grampoo	28	48	14	28	118
29	*Eugenia jambos*	Chamba	25	8	5	13	51
30	*Ficus gibbosa*	Ethy	1	6	0	0	7
31	*Garcinia gummi-gutta*	Kudampuli	30	29	43	29	131
32	*Gmelina arborea*	Kumizhu	10	0	0	0	10
33	*Grevillea robusta*	Silver oak	46	309	1	2	358
34	*Litchi chinensis*	Rambootan	9	4	2	1	16
35	*Mangifera indica*	Mavu	65	6	30	28	129
36	*Michelia chambaca*	Chembakam	21	11	0	12	44
37	*Mimusops elengi*	Elengi	2	11	2	0	15

38	*Moringa oleifera*	Muringa	16	20	0	5	41
39	*Murraya koenigii*	kariveppu	10	4	13	3	30
40	*Myristica fragrans*	Jathi	75	90	42	40	247
41	*Oroxylum indicum*	Palakapayyani	2	8	2	0	12
42	*Peltophorum pterocarpum*	Copper pod	7	0	0	0	7
43	*Pongamia pinnata*	Ungu	0	7	3	2	12
44	*Pouteria campechiana*	Mottapazham	23	13	0	5	41
45	*Psidium guajava*	Pera	9	8	4	7	28
46	*Pterocarpus santalinus*	Red Sandal	31	54	7	8	100
47	*Punica granatum*	Mathalam	25	24	8	4	61
48	*Santalum album*	Sandal	44	69	2	8	123
49	*Saraca asoka*	Asokam	1	13	4	4	22
50	*Strychnos nux-vomica*	Kanjiram	10	5	1	0	16
51	*Swietenia mahagoni*	Mahagony	253	284	14	50	601
52	*Syzygium cumini*	Njaval	12	4	0	1	7
53	*Tectona grandis*	Thekku	919	474	119	159	1671
54	*Terminalia bellirica*	Thanni	15	25	23	0	63
55	*Terminalia catappa*	Badam	13	20	3	7	43
56	*Terminalia paniculata*	Maruthu	11	17	10	4	42
57	*Terminalia tomentosa*	Karimaruthu	8	12	0	0	20
58	*Wrightia tinctoria*	Danthapappala	1	6	0	0	7
	Grand total		**2741**	**2497**	**633**	**764**	**6595**

D -Dry zone, **H** -High Range zone, **K** -Kolezone, **C** -Central zone